



# Evaluation of Colombia economic index for the period 2020 to 2022 with artificial neural networks

## Evaluación del índice económico de Colombia para el período 2020 a 2022 con redes neuronales artificiales

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### Abstract

This article analyzes some of the important macroeconomic indicators in Colombia, such as the Consumer Price Index (CPI), the Gross Domestic Product (GDP), the Representative Market Rate (TRM), the Oil Price (BRENT and WIT) and COLCAP. The objective is to study Colombia's economic. The analysis was obtained with artificial neural networks on Colombian indicators data for the period 2001 to 2018 of the National Administrative Department of Statistics (DANE) and Bloomberg. Concluding, for Colombia, the last two cases are highly favorable for the economy, because they will generate a greater influx of dollars, allowing positive effects on the domestic product and the consumer price index.

**Keywords:** Neural networks; macroeconomic indicators; forecasts

### Resumen

Este artículo analiza algunos de los indicadores macroeconómicos importantes en Colombia, como el Índice de Precios al Consumidor (IPC), el Producto Interno Bruto (PIB), la Tasa de Mercado Representativa (TRM), el Precio del Petróleo (BRENT y WIT) y COLCAP. El objetivo es estudiar la economía de Colombia. El análisis se obtuvo con redes neuronales artificiales sobre los datos de los indicadores colombianos para el período 2001 a 2018 del Departamento Administrativo Nacional de Estadística (DANE) y Bloomberg. Se concluye que para Colombia, los dos últimos casos son altamente favorables para la economía, pues generarían mayor cantidad de dólares, permitiendo efectos positivos sobre el producto interno y el índice de precios al consumidor.

**Palabras clave:** Redes neuronales; indicadores macroeconómicos; pronósticos

JEL: C43, C45.

## INTRODUCTION

Economic growth is one of the main concerns of a country. The evolution of this is frequently presented by means of economic indicators, which allow knowing how the well-being of the inhabitants benefits or affects in a future period in general aspects, based on decisions at the economic and financial level of the rulers.

In the Colombian case, economic evolution has experienced two periods of exponential growth throughout the century, the first between 2003 and 2007, a period in which it became one of the countries with a prominent emerging economy after being considered as a failed state, as the United States proclaimed in the late 1990s, when the increase in the armed conflict occurred along with the political crisis, social economy, which meant a loss of state control over much of the territory, generating insecurity and distrust in the country (Hernández, Chumaceiro & Ravina, 2017).

The second was in the period 2010 to 2014, achieving an average growth rate of 4.8%, reducing the incidence of poverty from 41.6% to 28.2% and increasing international reserves from 10.8% to 12.5%. These facts allow the inhabitants of the country to have a better quality of life, a technological advance due to the strong foreign investment in the country and also, raise the expectations of investors.

## PRELIMINARIES

The most important indicator is the Gross Domestic Product (GDP) that measures the value of a country's economic activity. This calculates the production of goods and services that were made in a specific period of time.

In the case of Colombia, it is evaluated quarterly by the National Administrative Department of Statistics (DANE). The Price of Oil is the price given to a barrel of oil, which is considered as 180 liters of oil or 42 gallons. The price of Oil has oscillated in a range of 20 to 150 dollars, this may vary due to times of prosperity and consumption levels, amount of available reserves and important social events. The Representative Market Rate (TRM) is the amount of Colombian pesos that must be paid for a United States dollar. It is calculated based on the operations of buying and selling currencies of financial intermediaries, on the same day as the negotiation.

### *Oil price*

The most important raw material that exists is Oil and the most important indicator to be considered in this work since this can affect millions of people and, unlike the rest of raw materials, this affects all segments of our economy. Oil income is defined as the difference between the value of Oil production at international prices minus the costs of production. The variation of the price impacts firstly exporters, complicating their national accounts, foreign exchange income and fiscal numbers. For those economies' dependent on this, it is essential that the price of this does not last long at low prices, because it affects their entire economy and national income.

In the second instance, importers are affected, an increase in the price generates a benefit for them, by presenting greater utility in their businesses. It is known the relationship between economic crises and Oil prices shocks (Kilian & Vigfusson, 2014) since the behavior of Oil prices affects the performance of large economies, mainly that of the United States, while the behavior of this economy is decisive to explain the behavior of these prices and also, the relationships between the price are constantly studied and real economic variables, such as Gross Domestic Product (GDP), real exchange rate, foreign investment, fiscal balance, among others, as well as the relationship between changes in crude oil prices and producer prices in the sector (Archibold, Aguilera & Escobar, 2017; Hernández et al., 2017).

Mainly, a positive change in the price of Oil affects Gross Domestic Product (GDP) proportionally and with a lag of several periods, and when there is a negative impact on prices there is no evidence in the variation of Gross Domestic Product (GDP) and it is considered that the main channel for the transmission of Oil prices to Gross Domestic Product (GDP) occurs through effects on consumption which, given its high participation in the aggregate of production, is an important amplifier of shocks. On the other hand, there is a clear direct relationship for the inflation of the economy, where this is decisive for hyperinflation in producing countries.

Following Rincón, Lozano and Ramos (2008) an Oil price shock affects the behavior of the economies through different channels, as it was seen in the economic crisis of 2008. The first is the exchange that originates in the sudden entry of external resources that tend to reconsider the real exchange rate, for the resources that actually enter the economy as per the expectations that are generated. This phenomenon is shown in an increase in the consumption of imported goods and in the deterioration of the current account of the balance of payments.

The second macroeconomic transmission channel comes from the income effect derived from the improvement of the terms of trade, which is manifested in an increase in consumption. In this way, a revaluation of the real exchange rate is generated, which fed back the deterioration of the current account. Finally, the third transmission channel of the oil shock is the prosecutor, which initially manifests itself in an increase in public revenues, and even more so in those countries where this type of income is mostly appropriated by the State, as is the case with Colombia.

As an example, taken from Rincón et al. (2008), the economic history of Colombia exemplifies what happens during a period of Oil bonanza, such as that which occurred between the second half of the eighties and much of the nineties. During this period, unprecedented Oil findings were made, which initially meant a flow of external resources in the form of direct foreign investment for the development of Oil fields and transportation, and then, in the increase in export earnings.

Between 1990 and 1997 the real exchange rate appreciated 41% and the current account deteriorated 11 points of Gross Domestic Product (GDP). During this period, the appreciation of the peso was also due to foreign direct investment flows destined to finance privatizations and to the behavior of external credit aimed at the private sector, which was strengthened by the favorable interest rate differential. Between 2001 and mid-2008 the real exchange rate was revalued 29% and the current ac-

count deteriorated 2.2 points of Gross Domestic Product (GDP). The conclusions of (Rodríguez, 2011), indicate that the world Oil price is one of the causes of inflationary shocks in Colombia, and an impact on the Consumer Price Index (CPI) generates an impact on oil prices, in this case the WTI, and for the Colombian case, this impact can last three months.

### *Representative market rate*

The representative exchange rate of the market measures the amount of pesos that must be paid for a unit of foreign currency, called Representative Market Rate (TRM), in Colombia the dollar is taken as the base currency, being the currency most used in this country to make transactions abroad. This price varies due to the supply and demand of dollars in the Colombian market, when there is a greater supply than demand, that is, an abundance of dollars and few buyers, the exchange rate falls, while when there is less supply than demand, that is, there is a shortage of dollars and many bought, the rate goes up. Similarly, there are several types of exchange rate regimes:

- *Fixed exchange rate regime*

The Central Bank (the Bank of the Republic for Colombia) undertakes to keep the rate in equilibrium by means of a predetermined value, so that when there is an excess demand for foreign exchange, the bank supplies the necessary foreign exchange to the market to achieve the goal. And in the opposite case, the bank acquires the currencies to prevent the rate from decreasing.

- *Flexible exchange rate regime*

For this regime, the bank refrains from intervening and the rate is determined by supply and demand as a whole. In addition, the movements of the exchange rate will be referred to as: a) devaluation, referring to the movement towards a higher value of the exchange rate, that is, we must give more pesos for each dollar that is traded and b) revaluation, which will be the movement contrary to a devaluation, that is, we must give less pesos for every dollar traded. In the market there are two types of exchange rate, nominal and real. The first is the rate at which currencies are sold or bought, while the second reflects the true purchasing power of the national currency against one or several foreign currencies, also reflecting the competitiveness of Colombian products against foreign products.

Following Echavarría, Vásquez and Villamizar (2010) for the period 2000 to 2008, more than 18 billion dollars were purchased using different modalities, either by direct purchases and other options, under the currency condition, with the aim of compensating for disorderly conditions and correct excessive trends, for those cases such as inflationary pressure and net credit position chosen by the Central Bank. The exchange rate level rose when interest rates were low, inflation and country risk were high and when the central bank bought foreign exchange in the market.

On the other hand, inflation, interest rate and country risk increase volatility in the exchange rate, while exchange interventions, when the bank buys or sells currencies, reduced it. In addition, the effects of the intervention on its level and volatility lasted with consistent results for a period of one day, one month and one semester.

### *COLCAP*

COLCAP is a capitalization index which reflects the variations in the prices of the most liquid shares of the Colombian Stock Exchange (BVC), where the participation of each company is determined by the corresponding stock market capitalization value. It is an indicator of the profitability of investments in financial assets of variable income and in fact, allows to measure with scores the gains and losses made in an operation during a day of financial activities on the stock market.

The creation of this index began on January 15, 2008 with a base value of 1000 points, years later on November 1, 2013, COLCAP began to be the main indicator of the behavior of the stock market replacing the General Index of the Stock Market of Securities of Colombia (IGBC). This indicator serves to reflect the most liquid shares that are in the Colombian stock market, its interpretation is given as the interpretation of the majority of the indexes of the economy, they are average, and consolidated, and as this index is based on the stock price can be analyzed in a similar way, indicating that when this index goes up it has implications which shows that the market is gaining value, and if it goes down it implies that the market is losing value.

A tool for the analysis of COLCAP is to observe the behaviour of the weights of the different assets that compose it. The COLCAP is an index that is composed of a minimum of 20 shares and each of these as a maximum share has a percentage of 20%, the selection of the shares that will compose it is made on the last business day of the month of October. The periodicity of the shares that compose it is one year, since each year they are re-analyzed of which it will be composed, at this moment they are, Successful Warehouses, Avianca, Banco de Bogotá, Bancolombia, Cementos Argos, Cemex, Davivienda, Ecopetrol, Aval group, Nutresa group, among others.

Each quarter of the first section of the year, a review of the index is made to determine what is the weighting of the shares of each share within the basket that comprises it. In this way a constant update of the variations found is presented in the market capitalization, it is possible to add or withdraw shares from the basket by mergers, settlements, issues, among others. To update the components of the indexes, on the one hand there is the recomposition of the basket. The definition of the basket index is done annually ([Rankia Finance Colombia, 2012](#)).

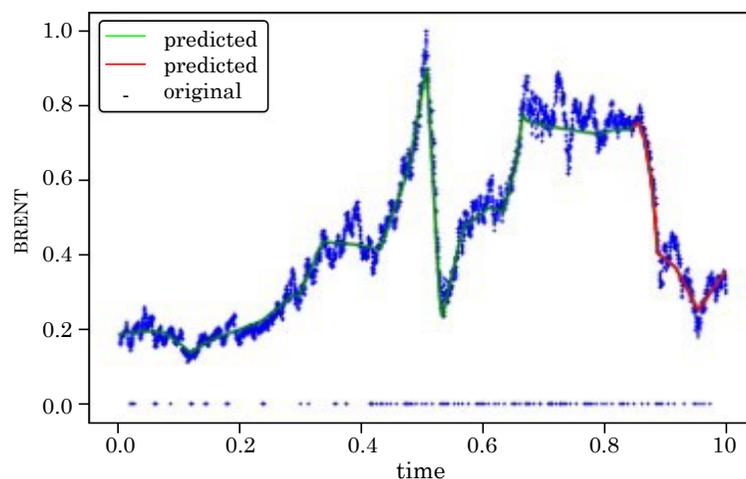
### *A neural network*

Neural networks are a new model, which is capable of self-learning and solving problems in the same way as the human brain, which have allowed imitating decisions against economic problems such as banking crises or forecasts of the exchange rate for time series.

A neural network seeks to minimize the cost function (or errors) which is evaluated through the entire network and the values of the weights for the network are adjusted. To avoid the problems of over dimensionality of the data in the network, the gradient descent is used, which is in charge of quickly finding an optimal weight for the minimum value of the function used, without affecting the dimension of the network. The stochastic gradient descent can also be implemented to adjust the weights of each row in the neural network and find the minimum globally faster and a comparison can be made between the output values of the network and the actual values, determining the errors and the data that harms the forecast.

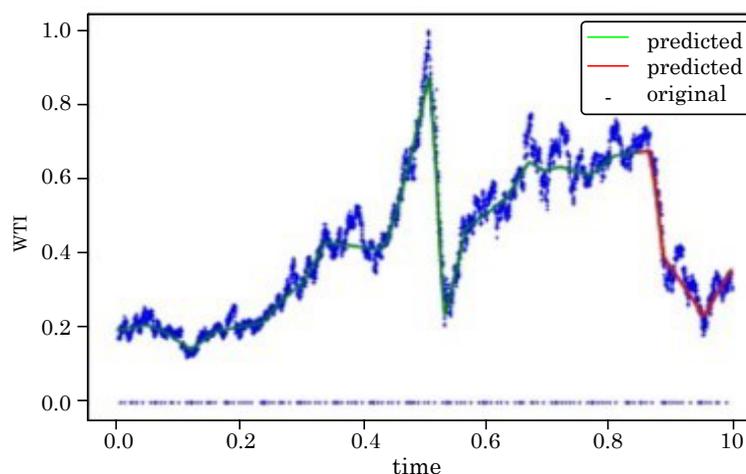
## RESULTS

**Figure 1** shows us the behavior of the price of BRENT oil on a daily basis for the period 2020 to 2022, which presents a downward trend.



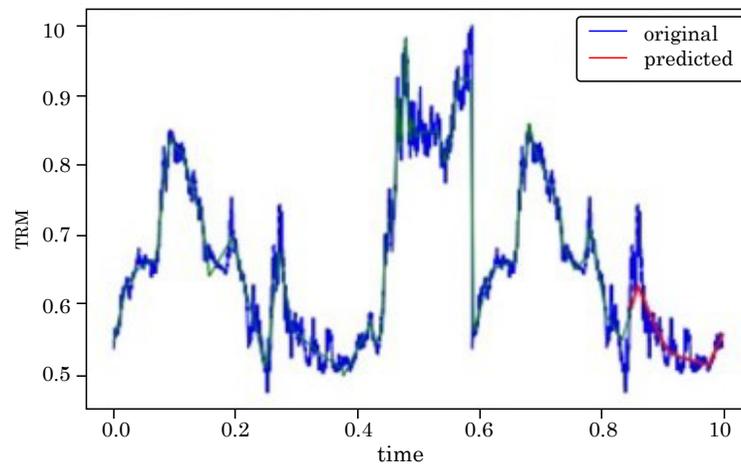
**Figure 1.** Forecast of the BRENT daily price in dollars for the period 2020 to 2022.  
Source: Authors.

**Figure 2** shows the behavior of the price of WTI Oil on a daily basis for the period 2020 to 2022, which presents a downward trend.



**Figure 2.** Forecast of the daily price of WTI oil in dollars for the period 2020 to 2022.  
Source: Authors.

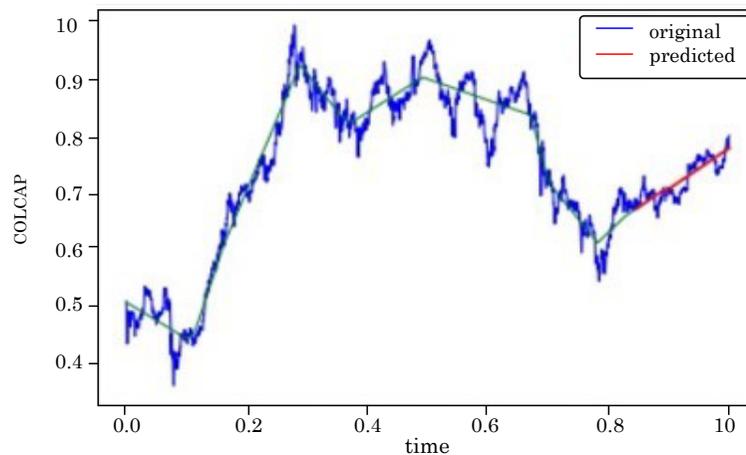
**Figure 3** shows us the behavior of the representative market rate on a daily basis for the period 2020 to 2022, which presents a downward trend



**Figure 3.** Forecast of the daily value of the representative market rate (TRM) for the period 2020 to 2022.

Source: Authors.

**Figure 4** shows us the behavior of the COLCAP on a daily basis for the period 2020 to 2022, which presents a uptrend.



**Figure 4.** Forecast of the daily value of the COLCAP for the period 2020 to 2022.

Source: Authors.

## CONCLUSIONS

As can be seen in the results obtained when forecasting the previous economic indices, there is a downward trend in the cases of Oil and the representative market rate and in the case of COLCAP there is an upward trend.

For Colombia, the last two cases are highly favorable for the economy, because they will generate a greater influx of dollars, allowing positive effects on the domestic product and the consumer price index, a scenario with less inflation in the products of the basic basket, that cause an increase in consumption.

In the case of investors, there may be greater savings compared to what they can currently do, because the Representative Market Rate will have lower values. This will allow a greater amount of investment in the stock market to be generated and since the COLCAP trend is bullish, higher returns will be obtained on the investments made.

The price of oil will have a considerable increase, as seen in its upward trend, it will have the economy to benefit in every way, generating a favorable scenario for exports, since these depend 50% on fuels and oil products, the extractive industry.

However, it must be borne in mind that oil volatility in recent years is a persistent problem to which Colombia will always be exposed. Therefore, adverse effects on the price of crude oil could lead to economic damage.

A proposal of great value for the Colombian economy, as indicated by the WTO, is to diversify its economy in order to continue with more accelerated growth, to place the losses of exports, such as oil and raw materials due to the rise in prices and inflation; and the increase in the representative market rate offset this growth, generating slowness in the measures taken for this purpose.

Since the Colombian economy is based, mainly, on the production of goods and services for export and the production of consumer goods, such as coffee, coal, gold, among others, it can be considered that this sector is one of The most important in the economy, and intuit that a variation in their prices and quantities produced imply a great impact on the economy. However, there are other sectors that can be activated and developed to achieve diversification, generate greater use of current resources and investments, and finally, solve and manage the economy in periods of crisis, generate a stronger economy and growth constant.

## REFERENCES

- Archibold, W., Aguilera, L. & Escobar, A. (2017). Revisoría fiscal y sostenibilidad empresarial en Colombia. *Económicas CUC*, 38(2), 77–88. <https://doi.org/10.17981/econcuc.38.2.2017.06>
- Echavarría, J. J., Vásquez, D. & Villamizar, D. V. (2010). Impacto de las intervenciones cambiarias sobre el nivel y la volatilidad de la tasa de cambio de Colombia. *Revista ESPE. Ensayos sobre Política Económica*, 28(62), 12–69. <https://doi.org/10.32468/Espe.6201>
- Hernández, J., Chumaceiro, A. & Ravina, R. (2017). Estado populista y gestión de políticas sociales. *Revista Negotium*, 38(13), 49–61. Available: <https://www.re-dalyc.org/pdf/782/78253678004.pdf>
- Kilian, L. & Vigfusson, R. (2014). The Role of Oil Price Shocks in Causing U.S. Recessions. [*International Finance Discussion Papers Number 1114*]. Available: <https://www.federalreserve.gov/pubs/ifdp/2014/1114/ifdp1114.pdf>
- Rankia Finance Colombia. (2012). ¿Qué es el COLCAP? [*Online*]. Available: <https://www.rankia.co/blog/analisis-colcap/1578756-que-colcap>

- Rincón, H., Lozano, I. & Ramos, J. (2008). Rentas petroleras, subsidios e impuestos a los combustibles en Colombia: ¿Qué ocurrió durante el choque reciente de precios? *Borradores de Economía*, (541), 1–24. Available: <https://www.banrep.gov.co/es/rentas-petroleras-subsidios-e-impuestos-combustibles-colombia-ocurrio-durante-el-choque-reciente>
- Rodríguez, H. Y. (2011). Estudio del fenómeno de inflación importada vía precios del petróleo y su aplicación al caso colombiano mediante el uso de modelos VAR para el periodo 2000-2009. *EG. Estudios Gerenciales*, 27(121), 79–98. [https://doi.org/10.1016/S0123-5923\(11\)70182-6](https://doi.org/10.1016/S0123-5923(11)70182-6)

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