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**ECONOMIC AND POLITICAL REFLECTION ON THE BREXIT EFFECT EUROPE –
PERU RELATIONSHIP**

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Abstract: *The key event that is expected to mark the beginning of the year 2021, will be the definitive transition out of the United Kingdom from the European Union, Brexit. Inquiring the key elements for a political and economic reflection, explained in terms of predictive mathematical models ARIMA, Holt-Winters and Lotka-Volterra, based on the historical variability of GDP in both nations from the Third Quarter of 2020 to the Third Quarter of year 2023. We show that the Republic of Peru will increase the variability in terms of gross domestic product GDP in relation to Brexit, with an exponential growth of 8,99% in the study period; going from US \$ 195868,147 to US \$ 213478,795. In conclusion, Brexit is a special regime with an emphasis on transaction. In conclusion, Brexit is a special regime with an emphasis on transaction costs, measured as the GDP response of cross-border trade companies in the United Kingdom and especially in relation to Peru.*

Keywords: Model, Prediction, Gross domestic product, Transition, Variability

Introduction

The year 2020 marked the expected exit of the United Kingdom from the European Union (EU), this phenomenon is known as Brexit. Therefore, it is worthwhile to investigate the impact of Brexit on the stability of the euro zone and its future relationship with the post-Brexit Republic of Peru, given that a trade agreement between the two nations is currently in place (Adler, Galpin and Rosamond, 2017). This bilateral trade agreement between Peru and the United Kingdom continues to be administered by the Trade Agreement with the European Union while the agreement signed between the European Union and the United Kingdom formalizes the exit of the latter (Gidron and Hall, 2017).

As spectators and partners of a democratic system at the global level, the main focus is to distinguish between signs and echoes of the post-Brexit transition from the first day of January 2021, taking as a scenario the beginning of the Brexit era, Europe-Peru relationship (Hecht, 2016; Oehler, Horn and Wendt, 2017). Brexit can have a big impact on the UK financial markets, depending on how it evolves over time (Sowels, 2017). Tension is mounting as the days go by, as internal political divisions make it difficult to reach a common ground; however, the possibility of a Brexit on such terms would bring major complications for all parties involved. The international financial agency Fitch Rating pointed out that, with a "hard Brexit", the risks of Britain entering a deep recession increase, as the market faces some signs of decline, such as a drop in sales due to consumer caution, loss of confidence in financial institutions and, according to Vikram (2021), warnings of possible closures of the automotive manufacturing industry, as pointed out by Ford and Mini.

From the investigation, the research question arises: Will Brexit as a political and economic project allow the Republic of Peru to increase the variability in terms of gross domestic product (GDP)? This is a difficult and determining question. The contribution of this research is to provide some of the key elements for a political and economic reflection (Beaumont, 2017), which will be answered in terms of predictive mathematical models, starting from the historical variability of the GDP in both nations from the Third Quarter of the year 2020 and project to the Third Quarter of the year 2023 (Norris and Inglehart, 2019; Virdee and McGeever, 2017).

1. Methodology

This is a documentary and descriptive type of research, since the data was located by consulting different types of historical documentation of the gross domestic product (GDP) (Horna, 2020), for Peru and the United Kingdom in the period 2016-2020 and projected for 2023, see Table 1. The empirical method used was observation and for data processing, descriptive, deterministic and stochastic statistical models (Ceballos and Rodriguez, 2020).

Table 1. Historical gross domestic product (GDP) for the United Kingdom and Peru, period 2016-2020.

Period	GDP-RU M\$	Var. Qtly- RU %	Var. Anu.- RU %	GDP-PE M\$	Var. Qtly-PE %	Var. Anu.-PE %
Oct-2015	614.212,83	0,40%	2,50%	168.985,32	1,9%	1,8%
Ene-2016	629.467,74	0,20%	2,10%	172.101,72	4,6%	4,4%
Abr-2016	591.012,18	0,60%	2,20%	185.804,08	2,3%	2,2%
Jul-2016	592.394,22	0,10%	1,10%	187.009,48	3,1%	3,0%
Oct-2016	623.169,36	0,70%	2,00%	191.684,72	2,5%	2,4%
Ene-2017	632.604,06	-2,20%	-1,70%	172.434,00	3,2%	3,1%
Abr-2017	637.965,90	0,50%	2,30%	190.826,00	3,9%	3,7%
Jul-2017	626.089,86	0,50%	1,90%	176.576,36	2,6%	2,5%
Oct-2017	592.691,22	0,30%	1,90%	196.209,11	5,6%	5,4%
Ene-2018	603.207,00	0,50%	1,30%	189.253,59	1,2%	1,2%
Abr-2018	624.554,37	-0,10%	1,40%	175.614,00	3,2%	3,1%
Jul-2018	519.808,41	-20,40%	-21,70%	180.710,83	4,8%	4,6%
Oct-2018	645.976,98	0,40%	2,10%	195.978,30	2,7%	2,6%
Ene-2019	583.366,41	0,50%	1,90%	180.990,77	2,5%	2,4%
Abr-2019	570.968,64	0,30%	1,80%	202.487,80	3,2%	3,1%
Jul-2019	598.943,07	0,60%	1,60%	189.596,00	4,7%	4,5%
Oct-2019	611.766,54	0,50%	1,30%	186.312,87	3,1%	3,0%
Ene-2020	663.709,86	0,50%	1,90%	200.485,80	2,3%	2,2%
Abr-2020	577.968,93	0,60%	1,80%	189.316,35	4,6%	4,4%
Jul-2020	585.633,51	0,40%	1,60%	206.132,58	1,8%	1,7%

Source: Own elaboration

1.1. Lotka-Volterra Model

Logistical growth is related to exponential growth, in fact for minimum values of the magnitude that presents logistical growth, this is very similar to exponential (Ramirez, 2017). However, after a certain period the curve adequately represents a prediction of gross domestic product: at the beginning these spread rapidly, each supply is susceptible to transfer the demand

to the period after it (Ulate, 2018). This typical application of the logistics equation is a common model of population growth according to which:

- The reproduction rate is proportional to the existing population.
- The reproduction rate is proportional to the amount of resources available.

The second term adjusts, therefore, the fairness of available resources, which tends to limit population growth (Cunha, Cândido, Oliveira and Penna, 2017). If P represents the subsequent GDP and t represents time, this model is formalized by the differential equation:

$$\frac{dP}{dt} = rP \left(1 - \frac{P}{K}\right) \quad \text{Eq. (1)}$$

Where the constant (r) defines the rate of variability and (K), is the capacity of persistence. The general solution to this equation is a logistic function. With an initial GDP:

$$P(t) = \frac{KP_0 e^{rt}}{K + P_0(e^{rt} - 1)} \quad \text{Eq. (2)}$$

1.2.ARIMA Model

The ARIMA model is an econometric methodology reflected in dynamic differential models that use time series data (Blanco & Hanco 2020). The systematic used in ARIMA models was first described by mathematician George Edward Pelham Box and engineer Gwilym Meirion Jenkins in 1970 in their book: Time Series Analysis, Prediction and Control.

For this research, the ARIMA model is fitted with an autoregressive term (AR (1)) and a seasonal differentiation term with a seasonal period of 12, the applied mathematical model is:

$$Y_t - Y_{t-12} = \gamma + \Phi(Y_{t-1} - Y_{t-12-1}) \text{Eq. (3)}$$

Where:

- Y_t real value in time t
- Φ term autoregressive
- γ constant term

Then it continues to be applied period by period until it reaches 12 and; calculate the gross domestic product GDP.

1.3. The Holt-Winters Statistician

The Holt-Winters multiplicative statistic is a robust technique for predicting time series with an additive tendency (Mejía and Gonzales, 2019). The recursive form of the Holt-Winters triple exponential smoothing equation is expressed as:

$$F_t(m) = (S_t + mb_t)C_{t-L+m} \quad \text{Eq. (4)}$$

$$S_{t>L} = \alpha + \frac{X_t}{C_{t-L}} + (1-\alpha)(S_{t-1} + b_{t-1}) \quad \text{Eq. (5)}$$

$$b_{t>L} = \varepsilon(S_t - S_{t-1}) + (1 - \varepsilon)b_{t-1} \quad \text{Eq. (6)}$$

$$C_{t>L} = \theta \left(\frac{X_t}{S_t} \right) + (1 - \theta)C_{t-L} \quad \text{Eq. (7)}$$

Where:

X_t is the value of the time series in time t .

L is the length of the season or duration.

S_t is an estimate of the smoothing of the level component.

b_t is an estimate of the smoothing of the trend component.

C_t is an estimate of the smoothing of the seasonal index component.

α is the level of smoothing coefficient.

ε is the trend of the smoothing coefficient.

θ is the seasonal smoothing coefficient.

$F_t(m)$ is the predicted smoothing value in the forward step m for X at time t .

Three simple exponential series, not dependent on level, trend and season, were assessed. They are interdependent in the sense that all three components must be updated every period (Dimitrov, Kraseta, Dimitrov and Parvanov, 2018). The study started from the historical GDP variation for the United Kingdom and Peru with a 12-quarter forward projection.

2. Results and discussion

2.1. GDP-Brexit Analysis: United Kingdom

Based on the historical GDP variation for the United Kingdom and Peru in Table 1, five mathematical models were applied to make decisions about the indicator that is directly affected by Brexit, given the variability in the quarters evaluated (Guera et al., 2019). It was projected through these, for twelve periods from October 2020 to July 2023. The following are the standardized results of the model:

(A) ARIMA (1,0,0) with constant

(B) Constant average = 606276

(C) *Lotka – Volterra* $P(t) = \frac{575730P_0e^{rt}}{575730 + P_0(e^{rt}-1)}$

(D) Simple moving average of 3 terms

(E) Simple exponential smoothing with alpha = 0,0581

Table 2 compares the results of five different forecasting models for gross domestic product (GDP). The model with the lowest mean absolute error (MAE) is model A. The model with the lowest percentage of mean absolute error (MAPE) is model A. MAPE estimates the average percentage of forecasting error one step ahead for GDP. The RMSE value expresses the amount of error between the data, i.e. between the prediction and the actual values (Gómez & Aguayo, 2019). For example, for model (A) the error is 4,00932% and so on with all models. Also the model (C) is one of the most accurate with an average error of 4,04754%.

Therefore, both the ARIMA model and the Lotka-Volterra trend predict a GDP growth value with an average accuracy of 96% for both.

Table 2. Forecast for GDP-UK

Model	RMSE	MAE	MAPE	ME	MPE
(A)	31998,9	23937,3	4,00932	113,463	-0,243751
(B)	31924,4	24676,2	4,13619	-8,44011E-11	-0,27564
(C)	32524,9	24221,2	4,04754	804,798	-0,136814
(D)	38376,6	30663,8	5,12473	-1365,42	-0,555278
(E)	32986,0	25492,8	4,26267	1720,42	0,000475556

Source: Own elaboration.

Table 3 shows the results of the Holt-Winters prediction, as a variation for GDP in millions of dollars per quarter. By July 2023 it is estimated that the GDP will reach a threshold of between US\$ 495291,786 to US\$ 654181,554 in growth over the current value. This model together with ARIMA and Curtva-S are within the range of prediction of the GDP, giving reliability to the study.

The GDP results confirm a downward trend forecast for the period 2021-2023; in line with economic forecasts and analyses that Britain will be, in the short and medium term, the big loser of Brexit. This was stated by ten Nobel laureates in the statement against Brexit, published in The Guardian newspaper, citing that "anyone who votes for Brexit with their heart will regret it with their brain" (El País, 2016). In theory, the ARIMA forecast explained a quarterly decline in GDP measured in US\$ 2000,00; this in turn will influence the per capita income of the population and overall supply and demand in the UK's national accounts. Britain's exit would reduce GDP by up to three percentage points under the assumption of an estimated cost of US\$ 920 per capita and a measured decline in income of four per cent. Accordingly, Oxford Economics (2021) estimated that Brexit will be 2/3 the size of the financial crisis of London's past, making Britain a net loser after the break-up of the European Union.

Table 3. Forecast of GDP-UK, for the period September 2020-June 2023

Period	GDP M\$	Holt- Winters(GD P MUS\$)	Waste	Lower limit (95%)	Upper limit (95%)
Oct-2015	614212,830				
Ene-2016	629467,740	614212,830	15254,910		
Abr-2016	591012,180	614536,336	-23524,156		
Jul-2016	592394,220	614359,691	-21965,471		
Oct-2016	623169,360	613719,208	9450,152		
Ene-2017	632604,060	613280,976	19323,084		
Abr-2017	637965,900	613251,729	24714,171		
Jul-2017	626089,860	613744,964	12344,896		
Oct-2017	592691,220	614497,917	-21806,697		
Ene-2018	603207,000	614787,386	-11580,386		
Abr-2018	624554,370	614833,105	9721,265		
Jul-2018	519808,410	615085,953	-95277,543		
Oct-2018	645976,980	613317,463	32659,517		

Ene-2019	583366,410	612249,577	-28883,167		
Abr-2019	570968,640	610566,431	-39597,791		
Jul-2019	598943,070	608045,973	-9102,903		
Oct-2019	611766,540	605335,800	6430,740		
Ene-2020	663709,860	602762,766	60947,094		
Abr-2020	577968,930	601481,677	-23512,747		
Jul-2020	585633,510	599696,841	-14063,331		
Oct-2020		597615,744		525865,801	669365,687
Ene-2021		595535,828		523769,753	667301,904
Abr-2021		593455,912		521625,601	665286,224
Jul-2021		591375,997		519401,552	663350,441
Oct-2021		589296,081		517066,280	661525,881
Ene-2022		587216,165		514589,325	659843,004
Abr-2022		585136,249		511941,606	658330,892
Jul-2022		583056,333		509095,996	657016,671
Oct-2022		580976,417		506027,908	655924,926
Ene-2023		578896,501		502715,848	655077,155
Abr-2023		576816,586		499141,852	654491,319
Jul-2023		574736,670		495291,786	654181,554

Source: Own elaboration.

Figure 1 shows the Holt-Winters exponential growth model for GDP in the United Kingdom. The red line indicates the stability in growth of the indicator from October 2020 to July 2023; appreciating an increase of 574736,670 thousand US dollars in relation to the previous period. The blue line shows the historical growth since the beginning of the Brexit since July 2016.

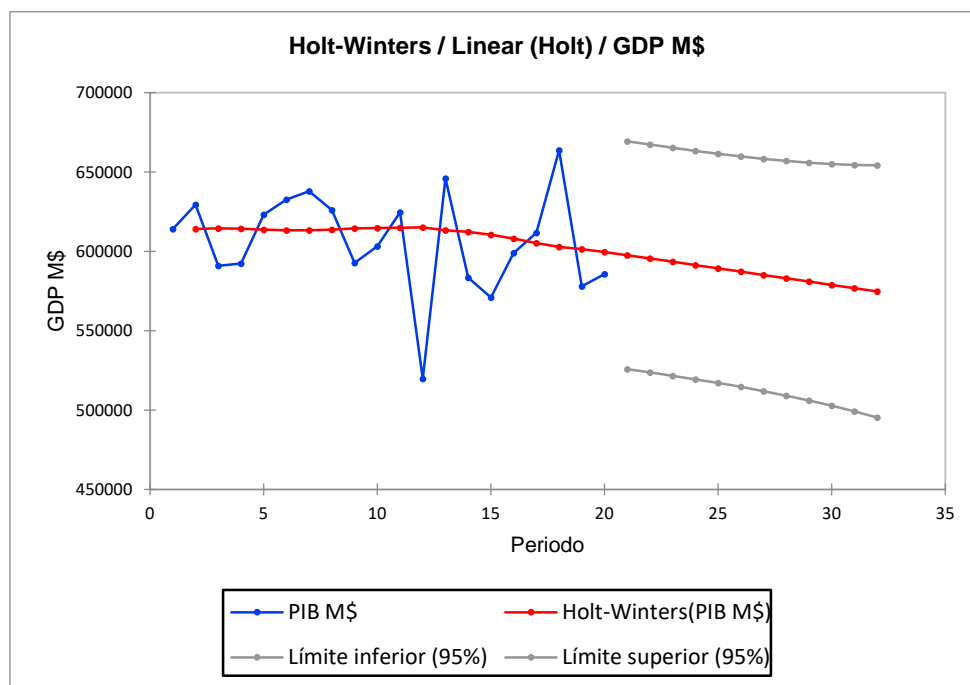


Figure 1. Holt-Winters threshold prediction model in the UK

Source: Own elaboration.

2.2.GDP-Brexit Analysis: Peru

In Table 4, the MAPE estimates the average percentage of forecasting error to be 36,713, a step ahead of the GDP, indicating that the forecast is accurate at a percentage difference of 63,287. The RMSE value for the series is 0,016 and shows the amount of error between the data, i.e., between the forecast and the actual values. In that sense, the forecast for the period from the third quarter of 2020 to the second quarter of 2023 quantifies a model accuracy of 98%.

Table 4. Goodness of fit for the Holt-Winters Model

Statistical	Value
Observations	20
GL	16
SEC	0,004
MEC	0,000
RMSE	0,016
MAPE	36,713
MPE	26,832
MAE	0,012
R ²	
Iterations	Yes

Source: Own elaboration.

Table 5 shows the results of the prediction in variation for the GDP in millions of dollars per quarter. By July 2023 it is estimated that the GDP will reach a threshold of between US\$ 179744,874 to US\$ 247212,716 in growth over current value. The purpose is to show the increase or variation of the GDP for Great Britain with a focus on the economic framework generated by the phenomenon analysed proposed above all in the correlation between the economic and political reflection on the Brexit effect on the Europe-Peru relationship. In this sense, in a moderate scenario, Great Britain would protect part of its permanence in the single market and could therefore continue to enjoy the export of products and services at relatively low prices due to the devaluation of the pound. However, imports would decrease due to the excessive increase in the price of imports, leading to a tendency towards self-sufficiency and a high dependence on key commodities such as oil. According to experts, the GDP deficit will be 6,90% and indicates that Britain will be a net borrower in the global economic context, depending on the good fortunes of foreign investors to finance its economy (Oxford Economics, 2021). In the context of the Peruvian economy, and at the local Latin American level, how does the UK's exit from the European Union affect Peru? Indeed, trade relations with the bloc are based on the Peru-EU free trade agreement and a long-standing bilateral investment agreement. Thus, with regard to the latter, as Semanario 948 points out, according to figures from ProInversión, in 2017, the British country was the second most important source of foreign direct investment in Peru, with US\$ 4336 million, only behind Spain (US\$ 4522 million), mainly destined for the mining, finance and telecommunications sectors, which accounted for 53%, 17% and 8% of the total, respectively. It is also important to mention that, in 2018, trade with Great Britain represented 8% of our trade with the EU (Confiep, 2019).

Table 5. Forecast of GDP-Peru, for the period September 2020-June 2023

Period	GDP M\$	Holt-Winters(GD P M\$)	Waste	Lower limit (95%)	Upper limit (95%)
Oct-2015	168985,320				
Ene-2016	172101,720	168985,320	3116,400		

Abr-2016	185804,080	169625,701	16178,379		
Jul-2016	187009,480	173032,142	13977,338		
Oct-2016	191684,717	176411,939	15272,778		
Ene-2017	172434,000	180425,665	-7991,665		
Abr-2017	190826,000	180060,660	10765,340		
Jul-2017	176576,365	183339,726	-6763,362		
Oct-2017	196209,108	183300,095	12909,013		
Ene-2018	189253,594	187124,948	2128,646		
Abr-2018	175614,000	189074,199	-13460,199		
Jul-2018	180710,832	187876,144	-7165,312		
Oct-2018	195978,302	187617,480	8360,822		
Ene-2019	180990,774	190360,725	-9369,951		
Abr-2019	202487,800	189680,489	12807,311		
Jul-2019	189596,000	193310,882	-3714,882		
Oct-2019	186312,868	193883,125	-7570,257		
Ene-2020	200485,803	193565,401	6920,402		
Abr-2020	189316,349	196026,156	-6709,807		
Jul-2020	206132,580	195868,147	10264,433		
Oct-2020		199021,599		176901,102	221142,095
Ene-2021		200335,889		177753,202	222918,576
Abr-2021		201650,180		178492,707	224807,652
Jul-2021		202964,470		179113,556	226815,385
Oct-2021		204278,761		179612,025	228945,497
Ene-2022		205593,051		179986,584	231199,519
Abr-2022		206907,342		180237,632	233577,052
Jul-2022		208221,633		180367,154	236076,112
Oct-2022		209535,923		180378,346	238693,501
Ene-2023		210850,214		180275,261	241425,167
Abr-2023		212164,504		180062,485	244266,524
Jul-2023		213478,795		179744,874	247212,716

Source: Own elaboration.

Figure 2 shows the Holt-Winters exponential growth model for GDP in the Republic of Peru. The red line indicates the stability of the indicator's growth from October 2020 to July 2023, appreciating a rise of \$2,378,795 thousand US dollars in relation to the previous period. The blue line shows the historical growth since the beginning of the Brexit since July 2016.

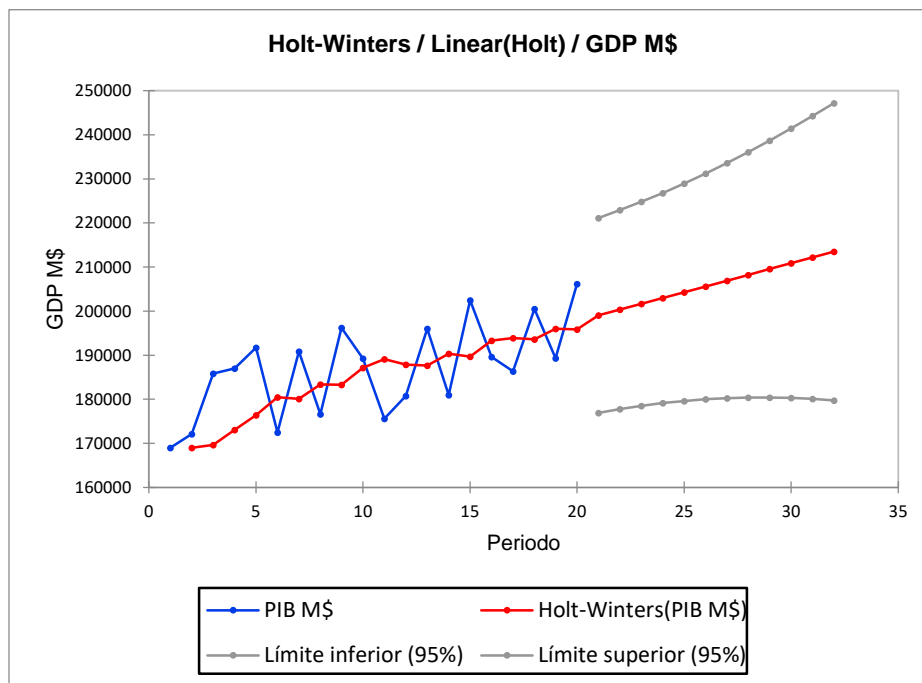


Figure 2. Holt-Winters threshold prediction model in Peru

Source: Own elaboration.

In summary, comparing the economic relationship of the United Kingdom and Peru measured in the gross domestic product (GDP) as the root of Brexit; the Republic of Peru will be the most benefited, because if we compare the Holt-Winters lines (GDP M\$) in Figures 1 and 2, the upward trend is more pronounced in mathematical terms of slope for Peru with an exponential growth of 8,99% between Jul-2020 (US\$ 195868,147) and July-2023 (US\$ 213478,795). This result confirms Confiep's economic analysis (2019), according to Sunat figures, between 2014 and 2018, exports to the UK grew at an average annual rate of 3,7%, from US\$ 607 million in 2014 to US\$ 704 million in 2018. Of the total exports in 2018, shipments of traditional products accounted for 42,1%, with a value of US\$ 296 million. Meanwhile, non-traditional exports accounted for 57,9%, with a value of US\$ 408 million, with those of the agricultural sector being the most representative, with US\$ 328 million. In summary, a possible exit of the United Kingdom from the European Union would imply maintaining a minimum average exponential growth of 8% in GDP, under the assumption of the Republic of Peru as a good foreign investor that will contribute to the finances of the British economy.

Conclusion

From the question: Will Brexit as a political and economic project allow the Republic of Peru to increase the variability in terms of gross domestic product (GDP), the answer is yes. The organizational contradictions of the United Kingdom's exit from the European Union, Brexit, are translated into a special regime in the transaction costs of companies in cross-border trade within Europe and in particular we highlight the importance of the treaty agreed between the United Kingdom and Peru (Hearne, 2020; Bulmer, 2014). These costs are historically reflected in gross domestic product (GDP) (Daddow, 2019). This is where the mathematical models came in to answer the question. Comparing the economic relationship of the United Kingdom and Peru as measured in gross domestic product GDP as the root of Brexit; the Republic of Peru will benefit most. The upward trend of the indicator for Peru, is observed in the exponential growth of 8,99% for the variability, between the period Jul-2020 and July-2023; from US\$ 195868,147 to US\$ 213478,795.

In this sense, the increase or variation of the GDP for Great Britain was demonstrated with a focus on the economic framework generated by the phenomenon analyzed proposed above all in the correlation between the economic and political reflection on the Brexit effect on the Europe-Peru relationship. In a moderate scenario, the UK would remain in the single market with the benefit of exporting products and services at relatively low prices due to the devaluation of the pound. Imports would decrease due to the excessive increase in the price of imports, leading to a trend towards self-sufficiency and a high dependence on key commodities such as oil. Negotiations for a post-Brexit trade agreement between Peru and the UK will continue to grow, and a major exit from the EU will guarantee continuity in the bilateral trade relationship once Brexit has taken place. At the same time, the UK has long confirmed its interest in the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), as well as its support for Peru's candidacy to join the Organization for Economic Co-operation and Development (OECD).

As a final reflection, the outlook is one of concern for the UK's European partners, as they have no incentive to do so and, more importantly, it would be a very attractive exit that could be demanded by other states, producing a domino effect initiated by Brexit.

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