



## Brexit: An Exploratory Analysis of the Macroeconomic Effects on the British Economy

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### Abstract

This paper investigates the effects of the Brexit announcement on the British economy. For this, we use a counterfactual analysis methodology, predicting a set of macroeconomic variables of the British economy in a scenario where the Brexit announcement did not happen and measuring what drifted away from its effective value. To forecast the variables we use the ARIMA method. Our conclusions are that if Brexit had not been announced: i) the exchange rate of the Pound Sterling against the US Dollar would not have had such a sharp depreciation trend; ii) real wage growth would not have been as high after the referendum; iii) the growth rate of the consumer price index would not have had such a strong growth trend and iv) the Gross Domestic Product would have grown at a higher pace and after three years of Brexit announcement it would have been 3% higher.

**Keywords:** Brexit; United Kingdom; European Union; ARIMA; counterfactual.

**JEL classification:** E17; F13; F15.

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### 1. INTRODUCTION

On June 23<sup>rd</sup> of 2016, the United Kingdom (UK) decided by referendum, with a majority of 51.9%, to leave the European Union (EU). This result was received with surprise, since most of the polls gave the victory to the “remain side”. The five months of campaign that preceded the referendum were marked by several controversies such as the use of social networks as an instrument of political propaganda<sup>1</sup> and the high number of false allegations and misinformation<sup>2</sup>.

Almost a year later, on March 29, 2017, the process dubbed Brexit begins, with the activation of Article 50 of the Lisbon Treaty. This article stipulates a maximum period of two years for the UK to leave the EU, which should take place on 29 March 2019. But after four postponements and two new Prime Ministers, it is only in 2020 that the process appears

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to be to see your end. With the passage of legislation by the deputies of the House of Commons, the UK is on its way out of the EU on 31<sup>st</sup> January 2020. It remains to be defined what kind of separation in commercial, economic and legislative terms, a negotiation that may take time a few more months. In fact, even after Brexit passed the British Parliament, the future for Europe and the UK is still uncertain and not very promising, particularly for the UK. The only certainty is that the reinstatement of the borders between UK and EU will have a negative effect on the British economy.

With this work we aim to understand if the Brexit announcement is already having an effect on the British economy, observing the effective behavior of four variables (Exchange Rate of the Pound against the US Dollar, growth of Real Wages, Inflation and Gross Domestic Product - GDP growth) and contrasting with a forecast of the behavior of these same variables if there had been no Brexit announcement. For this purpose, we will use the ARIMA - Autoregressive Integrated Moving Average model as a behavioral forecasting model for variables. Thus, we can see if there were deviations from the values observed in these variables.

In addition to the introduction, the work is organized as follows. In [Section 2](#) we will do a brief review of the literature, looking at the political relationship between the UK and the EU, the gains from integration between the two regions and forecasts of behavior on what the economic future of UK and EU will look like, once the separation occurs. In [Section 3](#) we will describe the data. In [Section 4](#) we will show the contrast of the ARIMA forecasts with respect to the effective values of the variables, finally ending this research with the presentation of the conclusions in [Section 5](#).

## **2. THE UK AND EU RELATIONSHIP: AN ANALYSIS OF THE PAST AND FUTURE**

Let us return to January, 1973. On this date, after several years of reluctance<sup>3</sup>, the UK joins the then European Economic Community<sup>4</sup> (EEC). However, the forty years spent in the European club were marked by a difficult marriage. Just two years after joining the EEC in 1975, the UK holds a referendum to decide whether to remain in the EEC. The stay-side won, with a majority of 67.2%. [Menon and Salter \(2016, p. 1298\)](#) define the UK as a recalcitrant partner, with a difficult relationship and with some distance mainly during the presidency of Margaret Thatcher. The authors further argue that this same awkwardness in relations may have contributed to the special treatment in several areas, such as in the formulation of the Maastricht Treaty, in the UK's desire to expand the Union to the east, the non-participation in the Euro nor in the Schengen area or the establishment of special rights and the legislation to be adopted.

The distance narrowed along the relationship. In the recent past, the successive Labor and Conservative governments of Tony Blair, Gordon Brown and David Cameron had strengthened relations and integration, but without ever letting go of the EU "scapegoat". It was precisely the double game that led David Cameron to propose a Brexit referendum on January 23, 2015, in a Conservative Party speech in Bloomberg that covered the subject of the UK's future relations with Europe. The idea behind the referendum was to appease the Eurosceptic voices within the party, without ever committing themselves to them, as the forecast was that "the remain" would win, as in 1975. Paradoxically, despite asking for the referendum, David Cameron participated, albeit anemically, in "the remain" campaign.

However, against all predictions, on June 23, 2016, Brexit was not defeated. The following day, on June 24, David Cameron resigns as Prime Minister. What followed, we will analyze in the following sections.

## 2.1 Growth estimations of the UK's membership of the European Union

Economic literature is unanimous<sup>5</sup> in the conclusion that greater integration between the UK and the EU has been beneficial to both sides. The difference is in the channels by which integration causes welfare gains and their quantification. Typically, the analysis done is a cost-benefit approach. Membership of the European club has an associated cost, which includes the contribution to the European Budget and the loss of national sovereignty regarding emigration and agricultural policy. The gains from integration result from access to an economic bloc with greater international negotiation capacity, the elimination of customs barriers and integration in the largest single market in the world.

In this section we will closely follow the work of [Crafts \(2016\)](#), which collects an extensive and complete bibliography that aggregates the different gains of the UK's entry into the EU. The author's main conclusions are that entry into the EU is responsible for an increase in the UK product, between 8%, to 10%. This conclusion is explained by several channels: increase in foreign trade, which in turn increases the productivity of factors by reducing the market power of companies on British soil and increasing competitiveness with the enlargement of the internal market throughout Europe. In addition, integration into the EU leads to an increase in Foreign Direct Investment (FDI), which is responsible for increasing the level of technology and for increasing productivity. [Campos \*et al.\* \(2014\)](#), cited in [Crafts \(2016\)](#), makes a counterfactual analysis of product growth after the country enters the EU, comparing it with several similar countries that did not. The authors conclude that entry into the EU had a significant impact on growth. Particularly for the UK, this impact, over the first ten years of membership was an increase of 8.6% of GDP, comparing with the counterfactual of the UK staying in European Free Trade Association (EFTA).

[Baier \*et al.\* \(2008\)](#), also cited in [Crafts \(2016\)](#), also concluded that for a country integrating with the EU, there is an increase in the volume of trade by 41.2% after 15 years of membership. In the case of the UK, this impact was estimated at 21.1% increase in the volume of trade versus remaining in the EFTA. [Feyrer \(2011\)](#) argues that the increase in the volume of exchanges increases well-being, measured variation of GDP, through increased productivity and increased capital stock. This channel can be measured through the elasticity of income in relation to trade<sup>6</sup>, developed in [Feyrer \(2011\)](#), which is concluded to be between 0.5, to 0.75. [Crafts \(2016\)](#), using the conclusions of the increase in the volume of Baier exchanges (21.1%) and the lower limit of the elasticities of Fayer (0.5), also concludes that entry into the EU increased British income by 10.6%.

In terms of costs of being a member of the EU, [Crafts \(2016\)](#) also surveys the costs of being in the EU. The possible losses highlighted by the author are in the area of migration, imposition of regulation, Common Agricultural Policy (CAP) and contribution to the European Budget. These themes were central arguments raised by the campaign for Brexit and a concern of many of the citizens who expressed their desire to leave the EU. [Dustmann and Frattini \(2014\)](#), also cited by [Crafts \(2016\)](#), also concludes that these costs are not as big as the campaigns for the exit advocated, around 1.4% of GDP. In more detail, in the area of migration it is difficult to accurately calculate costs. Between 1990 and 2011, immigrants

from the European Economic Area residing in the UK increased from 0.9 to 2.8 million Europeans living in the UK, but these are a net taxpayer for the British economy of GBP 28.7 billion at 2011 prices. On the other hand, in the report of the [Migration Advisory Committee \(2011\)](#), it is explained that this number of migrants is responsible for an increase in productivity. For these reasons, it is difficult to prove that migration within the European Economic Area is truly a cost.

In the area of regulations imposed by Europe, according to [Gaskell and Persson \(2010\)](#), cited in [Crafts \(2016\)](#), these are responsible for spending 0.9% of GDP and usually have a net benefit. But according to [Crafts \(2016\)](#) the regulation has little impact on the economy, when compared to other European countries. The author reaches this conclusion based on the score of the UK on the indicators Product Market Regulations and Employment Protection Regulation, occupying, in 2013, the second and third place, respectively, within OECD countries. Another cost is the contribution to the European Budget, which varies between 0.3% and 0.6% of GDP ([Webb et al., 2016](#)). Finally, the CAP with an associated cost of 0.5% of the product, described in [Philippidis and Hubbard \(2001\)](#). In this regard, [Crafts \(2016\)](#) writes that the CAP “has clearly been disadvantageous to the UK due to its relatively small agricultural sector” ([Crafts, 2016, p. 8](#)). [Table no. 1](#) summarizes the benefits and costs of membership in the EU described above.

**Table no. 1 – Benefits and Costs of UK’s membership in the EU**

Benefits	Costs
GDP increase of 8.6% of GDP, <a href="#">Campos et al. (2014)</a> (Counterfactual to remain in EFTA)	Free movement of people - Hard to prove if it’s a truly a cost as EU migrants are a net fiscal contributor
Increase in the volume of exchanges by 21%, <a href="#">Baier et al. (2008)</a> Elasticity of GDP to Trade of 0.5 (lower bound), <a href="#">Feyrer (2011)</a>	Regulation imposed by EU - UK scores top 3 in regulation’s impact on economy (OECD countries)
Conclusion: 10.5% increase in GDP	Contribution to the EU budget - between 0.3% and 0.6% of GDP
Conclusion: Integration into the EU was economically beneficial for the UK	Common Agricultural Policy - 1.1% of GDP

*Source:* Based on [Crafts \(2016\)](#)

Adding the costs, [Crafts \(2016\)](#) concludes that the costs of belonging to the EU are around 1.4%, well below the 8% to 10% of GDP growth of belong to the EU. Thus, we can conclude that joining the EU bloc was beneficial for the UK economy.

## 2.2 Soft or Hard Brexit

Brexit options splits in two different options to choose: Soft or a Hard Brexit. However, none of the options were on the table at the time of the referendum, which makes the options for choosing policy makers even more difficult. The Hard Brexit, as it is popularly dubbed, consists of the most radical cut between the UK and EU. Trade would now take place under the terms of the “most-favored-nation” of the World Trade Organization (WTO). This is by far the worst scenario, in economic terms. The Soft option, or Soft Brexit, happens with an agreement between the UK and the EU. On the negotiating table will be the option for the UK to join the European Economic Area and thus maintain

access to the Single Market (also known as the Norwegian Option) or join the EFTA. On the other hand, Soft Brexit can also follow the path of the bilateral agreement, in which both parties negotiate each point of the trade agreement. In this case, the process of negotiating a Trade Agreement between the UK and the EU may take several years to complete. An example of this is the trade agreement between the EU and Canada, which started to be negotiated in 2008 and was only concluded in 2014.

One of the main points of contention on the negotiation between UK and the EU is Irish border question and the Good Friday Agreement, which brought peace to the Irish island. Former Prime Minister Theresa May tried to “push” an agreement dubbed Irish Backstop. Backstop, in baseball world, is the net that protects the spectators from the lost balls. As the name implies, this option was kind of safety net. The EU and the UK have always agreed that the reposition of physical borders within the Irish island was something to avoid. Irish Backstop would create an extraordinary situation where the UK would be aligned with customs policy like the rest of Europe, until a new agreement emerges between the two parties. But this solution wasn’t approved by the British Parliament, which argued that Brexit with the backstop was not really an exit and could jeopardize UK unity. With the resignation of Theresa May on May 24, 2019, the Irish Backstop mechanism was scrapped. On July 2019, Boris Johnson comes to power with a promise to strike out and replace the Irish Backstop. He also promises to move forward with the UK leaving the EU by October 31 or “ending up dead in a ditch”<sup>7</sup>.

The agreement that Boris Johnson presented in October 2019 differs from that of Theresa May in exchanging the Backstop agreement for a period of 4 years in which Northern Ireland and the EU are aligned in terms of borders and customs issues. This would place the border between the British and the Irish island, thus allowing to fulfil the Good Friday agreement. The departure on 31 October did not happen, but Boris Johnson achieved what Theresa May did not: the agreement that he brought from negotiations with the EU was discussed in the British Parliament, with the green light of Parliament on 22 October. Boris Johnson tries to have the agreement discussed and accepted within three days in order to fulfil the commitment to leave on 31 October, which is rejected by the British Parliament. This lead leads the Prime Minister to call for early elections, on the 12th December, with Boris Johnson winning these elections with the majority necessary to control Parliament and to pass, on 9 January 2020, the UK exit law from the Union. EU which is expected to take place on 31 January 2020.

After 31 January 2020, the UK will be officially out of the EU. But on February 1, the UK will not be radically different. On this day and until 31 December 2020, the UK will enter a transitional period where the UK will continue to abide by EU member rules, although formally it is no longer a member. It is during this period that the UK will have to negotiate all exit points with the EU, a major challenge, which many consider impossible. If necessary, the UK and the EU have until 1st of July 2020 to request a two-year extension of the transition period. Prime Minister Boris Johnson has stated that he intends to negotiate, during the transition period, a trade agreement that will put the UK outside the customs union and the single market. If the UK is unable to negotiate a deal, a Hard Brexit, where trade is done under “Most-Favoured-Nation” terms is not out of the question for Boris Johnson government<sup>8</sup>.

### 2.3 Forecasts for the economic effects of Brexit in the United Kingdom

Once the exit options have been considered, we can proceed with the economic forecasts of the impact of Brexit, be it Soft or Hard. Despite the various methods for calculating the impact of Brexit, the economic literature agrees that it will decrease the volume of exchanges and, directly and indirectly, decrease the welfare of citizens, measured through the GDP. This is because the UK is a small economy with great openness to the outside, so an increase in friction to foreign trade will have a negative impact on UK's economy. "In some ways, Brexit would be similar to a GDP tax, imposing a persistent and growing cost to the economy that would not be incurred if the UK remained in the EU" (Kierzenkowski *et al.*, 2016, p. 6).

Based on the idea that Brexit will decrease the volume of trade between the UK and the EU, economic literature<sup>9</sup> is divided into two distinct ways of predicting the effect of Brexit: i) analysis of the effects on the volume of exchanges, hereinafter referred to as the direct effects method, or ii) analysis of the effect that the reduction of integration between the UK and the EU has on the economy, not only on decreasing the volume of exchanges but on a series of other channels such as migration, FDI, human capital and knowledge spillovers, hereinafter referred to as the indirect effects method. In the latter method, the impact of Brexit is usually larger.

Dhingra *et al.* (2017) studied the direct effects of Brexit on the degradation of trade and successively on the British GDP. To calculate the decrease in trade that may occur as a result of Brexit, the authors used a quantitative trade model based on the Eaton-Kortum General Equilibrium Model, which is a Ricardian international trade model that incorporates the role of geography in costs.

These costs, depending on the location, can be transaction costs, customs barriers, costs of legal differences between countries. The sample covers 31 industrial sectors in 35 countries and simulates two scenarios: Hard Brexit, that is, the UK would apply the Most Favoured Nation's World Trade Organization tariffs and Soft Brexit scenario, where the UK remains in the European Single Market, which means that there are no tariffs between the two blocks. This analysis allows, in each scenario, to try to quantify the effects of the imposition of barriers via three different channels: immediate change in tariffs; immediate change in non-tariff barriers and, finally, the UK's exclusion from future trade integration between EU countries.

To calculate the last two effects (non-tariff barriers and excluding of future trade integration of European countries), Dhingra *et al.* (2017) make the following hypotheses, respectively: i) non-tariff barriers<sup>10</sup> that the UK will face when leaving the EU are of  $\frac{1}{4}$  of those that the United States of America currently have when exchanging with the EU in an optimistic scenario and  $\frac{3}{4}$  in a pessimistic scenario. This hypothesis leads to an increase of 2.77% and 8.31% in customs costs, respectively in an optimistic or pessimistic scenario. ii) Assuming EU countries are continually deepening their integration, this means that non-tariff barriers between EU countries are continually falling.

The authors assume that these costs among EU countries fall 40% faster than among OECD countries. In a pessimistic simulation, when leaving the EU these costs of non-customs barriers stop falling between the UK and the EU. In an optimistic scenario, costs between EU countries decrease slowly by 20% instead of 40%, while the hypothesis remains that the costs of trade between the EU and the UK do not decrease further.

With these premises, [Dhingra et al. \(2017\)](#) simulate the pessimistic and optimistic scenarios and conclude that if the UK opts for a Soft Brexit, UK GDP decreases by 1.34%, when compared to the counterfactual of staying in the EU. In per capita terms, this loss means that each Briton will be poorer 893 British Pound (GBP) annually. In the pessimistic scenario, welfare decreases by 2.66%, which would result in a loss of 1773 GBP per capita. These effects are documented in summary form in [Table no. 2](#).

**Table no. 2 – Forecast of per capita costs of Brexit, soft versus hard Brexit**

	Direct Effects	Indirect Effects
<b>Soft Brexit</b>	893 GBP per capita	4200 GBP per capita
<b>Hard Brexit</b>	1773 GBP per capita	6266 GBP per capita

Source: [Dhingra et al. \(2017\)](#)

The direct effects analysis is useful given its great modeling capacity, since changing the initial assumptions of direct and indirect costs we quickly reach different conclusions. However, it does not allow to capture some of the effects that greater integration and trade between nations has. At issue is that the level of technology in this type of model is treated as exogenous. Economic theory dictates that, in addition to directly increasing income, a higher level of trade can increase a country's technology, via increased foreign investment, migration, increased competitiveness by opening the national market to foreigners and spillover effects of knowledge<sup>11</sup>.

Synthetically, [Feyrer \(2011\)](#) calculates an income elasticity in relation to trade between 0.5 and 0.75 that captures the indirect effects that the increase in trade between countries causes. It is for this reason that in the analysis of [Dhingra et al. \(2017\)](#), where the indirect effects of trade are considered, the reduction in well-being is greater than in the simple analysis of direct effects.

In the same work, [Dhingra et al. \(2017\)](#) build yet another model based on gravitational trade models. These gravitational models study the effects of EU membership and their effects on increasing the volume of exchanges. [Baier et al. \(2008\)](#) concluded that entry into the EU makes countries exchange more with each other and that an exit from the EU and EFTA membership would lead to a 25% decrease in the volume of UK trade with countries from the EU.

Assuming that the volume of trade with countries outside the EU does not change and considering an income elasticity in relation to trade from 0.5 to 0.75, based on the analysis by [Feyrer \(2011\)](#), [Dhingra et al. \(2017\)](#) conclude that Brexit will have an impact of 6.3% to 9.4% on British income. In [Table no. 2](#), the indirect effects approach is also expressed in per capita terms.

### 3. DATA

In the previous sections, the impact of the UK's entry into the EU was analyzed, from an essentially theoretical point of view. In addition, we look at the future of the UK outside the EU and the economic impacts of Brexit. However, the aim of this work is also to try to understand if the Brexit announcement and the subsequent deadlock had an impact on the British economy. To try to measure the impact of the Brexit announcement, we will look at the effects of the announcement on a set of macroeconomic variables. These variables are

the British Gross Domestic Product at constant 2015 prices, the exchange rate of the British Pound against the US Dollar, inflation, measured by the variation of the UK Consumer Price Index, and the growth in wages (adjusted for inflation). All data ranges from 1973 to 2018, with an annual frequency. The choice of the initial date is because in 1973 the UK joined the then EEC, which would later become the current EU.

The exchange rate is quoted directly for the British Pound (GBP). We opted to choose the exchange rate against the US dollar since if we had chosen to choose to measure the exchange rate against the Euro, this analysis might not really capture the post-Brexit depreciation dynamics as Brexit also affects the Eurozone's economy. By choosing a currency "further away" from Brexit dynamics, we can better capture the effects of Brexit. The exchange rate data was taken from AMECO, which only had the exchange rates available for US Dollar and British Pound against the Euro/European Currency Unit. In order to transform the Pound Sterling against the US Dollar, we divide the Euro/Pound exchange rate by the Euro/Dollar exchange rate to obtain the direct relationship between the two currencies, by crossing the previous ones.

In turn, real wage growth was calculated using data on gross nominal wages (also taken from AMECO), expressed in Pounds and dividing each observation by the respective value of the Consumer Price Index (CPI). Finally, to obtain an approximation to the growth rate, we applied the logarithm and first differences. Regarding the Consumer Price Index, this variable is based in 2015 (2015 = 100) and was also taken from AMECO. The growth rate of the CPI was considered an approximation to the inflation rate.

Finally, the growth of the GDP was calculated by transforming the GDP series at constant 2015 prices. The transformation consisted of applying the logarithm and then first differences in order to obtain the GDP growth rate. This series was also obtained from the AMECO<sup>12</sup> database.

#### **4. IMPACT OF THE BREXIT ANNOUNCEMENT ON THE BRITISH ECONOMY: A COUNTERFACTUAL ANALYSIS**

Once the data is chosen, the question arises of how to measure the impact of something that has not yet happened. Remember that our goal is to try to measure how much the value of the set of variables under analysis has deviated from the effective value. We do this by forecasting the years 2016, 2017 and 2018 if the Brexit announcement had not taken place, *ceteris paribus*, and comparing with the effective behaviour of said variables. This is also known as a counterfactual analysis. The forecasting of data after Brexit announcement will be done using an ARIMA model for each variable.

##### **4.1 The ARIMA model**

As previously mentioned, the model used to forecast the behaviour of variables for the three years after the 2016 referendum will be the ARIMA model. The choice of this model is since it is a powerful tool when the intention is to forecast based on past values. In this section, we will briefly explain how the ARIMA process works, thus justifying our choice.

The word ARIMA comes from the acronym Auto Regressive Integrated Moving Average. Forecasts based on the autoregressive (AR) method are a linear combination of past values. An order regression  $p$ , or AR ( $p$ ), can be written as follows:



$$y_t = c + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \dots + \varphi_p y_{t-p} + \varepsilon_t \quad (1)$$

where  $\varepsilon_t$  is a white noise. By white noise, we mean that the errors do not have autocorrelation, or that the errors are not dependent on the past values. The second component of the ARIMA process is called the Moving Average (MA). This process uses, through a linear combination, past errors to predict future values. A MA process of order  $q$ , or MA( $q$ ), will take the form:

$$y_t = c + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \dots + \theta_q \varepsilon_{t-q} \quad (2)$$

As in the AR process, in the case of the Moving Average process the error term  $\varepsilon_t$  is white noise, that is, not depending on its past values. The combination of the autoregressive process and the moving average process gives the new process dubbed ARIMA. The component “I”, which stands for integrated, is the number of differentiations that the model needs for the variables to be stationary. By stationarity, it is understood that regardless of the time interval of the series that we choose, it maintains its characteristics.

#### 4.2 Stationarity

Forecasting through the ARIMA process is condition to the stationarity condition. In a stylized way, for a series to be stationary it needs to obey three conditions over time:

Constant average:

$$\forall_t, E(Z_t) = \mu \quad (3)$$

Constant variance:

$$\forall_t, V(Z_t) = \sigma_Z^2, \quad (4)$$

The same auto covariance function over time:

$$\forall_t, \forall_S, \forall_K, E[(Z_t - \mu)(Z_{t-K} - \mu)] = E[(Z_S - \mu)(Z_{S-K} - \mu)] = f(K) \quad (5)$$

Complying with equations (3), (4) and (5) is the same as saying that it has the same characteristics over time. In the case of our series, the stationarity condition is no exception. In order to verify whether our data is stationarity, we opted to apply two tests, which allows greater robustness in the analysis. These tests are the Augmented Dickey Fuller (ADF test), whose null hypothesis is the existence of a unit root and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS test), with null hypothesis of the series being stationary. As usual, we observed the p-value associated with the test and rejected the null hypothesis in cases where the p-value is below 5%. [Nussair \(2003\)](#) presents a summary table about the two tests and the stationarity decision that we reproduce in [Table no. 3](#).

[Table no. 4](#) shows the results of the KPSS and ADF tests applied to each of the variables. Except for the CPI and the Exchange Rate, all variables are stationary. For the CPI growth and the Exchange Rate, first differences were applied in order to obtain stationarity of these variables.

**Table no. 3 – Decision matrix for KPSS and ADF tests**

KPSS test	ADF test	
	Does Not Reject $H_0$	Rejects $H_0$
Does Not Reject $H_0$	Inconclusive Decision (Insufficient Information)	Stationarity
Rejects $H_0$	Non-Stationarity	Inconclusive Decision (Fractional Integration)

Source: Nussair (2003)

**Table no. 4 – KPSS and ADF tests results and order of integration**

Variable	Test	At level (p-value)	First difference (p-value)	Conclusion
Exchange Rate	KPSS with constant and trend	$0.05 > 0.03 > 0.01$ (Reject $H_0$ at 5% level)	$p\text{-value} > 0.1$ (accept $H_0$ )	Integration of order 1 I(1)
	ADF With constant and trend	$0.0055 < 0.05$ (Reject $H_0$ )	$0.0003$ (Reject $H_0$ )	
Real Wage Growth	KPSS With constant	$p\text{-value} > 0.1$ (Accept $H_0$ )	-	Does not need differentiation I(0)
	ADF With constant	$0.0021 < 0.05$ (Reject $H_0$ )	-	
Consumer Price Index	KPSS With constant and trend	$p\text{-value} < 0.01$ (Reject $H_0$ )	$p\text{-value} > 0.1$ (Reject $H_0$ )	Integration of order 1 I(1)
	ADF With constant and trend	$0.1039 > 0.05$ (Accept $H_0$ )	$0.00892 < 0.05$ (Reject $H_0$ )	
GDP Growth	KPSS With constant	$p\text{-value} > 0.1$ (Accept $H_0$ )	-	Does not need differentiation I(0)

Source: Author's calculation using Gretl software.

### 4.3 Choosing the ARIMA model

As explained in Section 4.1, once the stationarity criterion of the variables is met, it is necessary to choose the AR(p) and MA(q) parameters of the ARIMA model. On our first step, the sample of our variables which ranges from 1973 to 2018, was subdivided into a training sub-sample. This training sample consists of the years 1973 to 2012. With this training sample we will pseudo-predict the years 2013, 2014 and 2015 experimenting with a series of ARIMA models with different  $p$  and  $q$  parameters. In this pseudo-forecast for the years 2013 to 2015, we have chosen a model that, in our opinion, capture the series trend well, that is, the pseud-forecasts from 2013 to 2015 that come closest to the effective values for that same range of years (of 2013 to 2015).

From this series of different models, we used three different methods to choose the best model to truly forecast the years of 2016 to 2018. These criteria being the minimization of the Aikaike Information Criterion (AIC), minimization of the Root Mean Square Error (RMSE), and minimization of Theil's U conditional on this value being less than 1. Fulfilling the three criteria, we can define which is the best ARIMA for the years 2013, 2014 and 2015 that comes closer to reality and thus decide which one to use to predict the

variables in the years after Brexit announcement (years 2016, 2017 and 2018). In Table no. 5, we can see which ARIMA model was chosen for each variable and the values of the three criteria for choosing the ARIMA model for each variable.

**Table no. 5 – Parameters of the ARIMA model for each variable**

Variable	AIC	RMSE	Theil's U	ARIMA (p,d,q)
Exchange Rate	-32.887	0.056409	0.69076	(1,1,2)
Real Wage Growth	-160.836	0.0089274	0.49485	(1,0,0)
Inflation	-185.212	0.0079962	0.94443	(4,1,2)
GDP Growth	-178.192	0.0034792	0.61947	(2,0,0)

Source: Author's calculation using Gretl software.

#### 4.4 ARIMA forecasts

In this section we present the predicted values for the four variables, using the ARIMA method. We will then do the counterfactual analysis based on the values that effectively occurred.

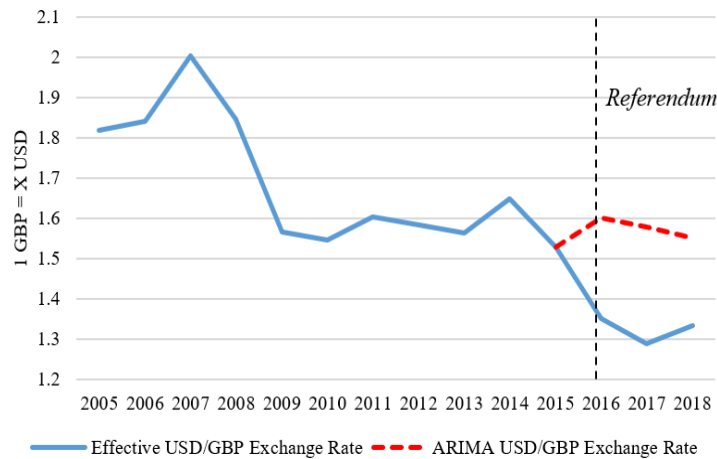
##### 4.4.1 Exchange rate

Table no. 6 shows the values predicted by the ARIMA model and the actual exchange rate values for the GBP against the US Dollar, for the three years after the 2016 referendum. In Figure no. 1, it is graphically illustrated the forecast and effective values.

**Table no. 6 – Forecast and effective values of GBP exchange rate against the USD**

Year	ARIMA Forecast (No Brexit announcement)	Effective value (With Brexit announcement)
2016	1.601 USD = 1 GBP	1.351 USD = 1 GBP
2017	1.580 USD = 1 GBP	1.289 USD = 1 GBP
2018	1.552 USD = 1 GBP	1.335 USD = 1 GBP

Source: Author's calculation using Gretl software.



Source: Author's calculation using Gretl software

**Figure no. 1 – Dollar/Pound exchange rate, forecast and effective values**

As can be seen in [Table no. 6](#) and [Figure no. 1](#), if the Brexit announcement had not happened, the British Pound would have had a value ranging between 1.6 USD = 1 GBP and 1.55 USD = 1 GBP, for the years 2016 to 2018. This would mean the GBP exchange rate against the USD would have shown a slight depreciation trend. Comparing the two situations, we are then led to conclude that the Brexit announcement caused the Sterling Pound to depreciate against the US Dollar even more sharply.

#### 4.4.2 Real wage growth

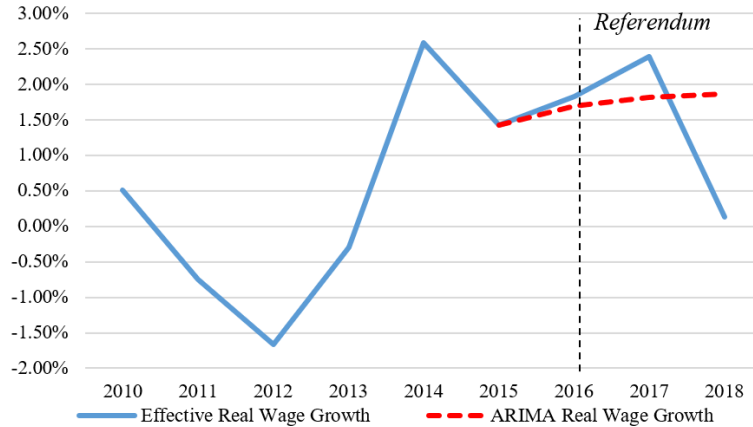
In [Table no. 7](#) is presented, in percentage, the growth of real wages predicted by our ARIMA model and the effective values for the years 2016 to 2018. In [Figure no. 2](#), these same values can be observed graphically.

**Table no. 7 – Forecast and effective values of Real Wage growth**

Year	ARIMA Forecast (No Brexit announcement)	Effective value (With Brexit announcement)
2016	1.69%	1.82%
2017	1.81%	2.39%
2018	1.86%	0.13%

Source: Author's calculation using Gretl software.

The behavior of the Real Wage growth is curious. Forecasts for Real Wage growth behavior are below the effective values in the first two years after the Brexit announcement, meaning that had the Brexit announcement not taken place, real wages would have grown less compared to the actual situation.



Source: Author's calculation using Gretl software.

**Figure no. 2 – Real wage growth (%), forecast and effective values**

We conclude, therefore, that the Brexit announcement did not have an immediate negative impact on real wage growth. However, the same cannot be concluded in 2018, when the Brexit announcement led to a lower growth in real wages (0.13%), when

compared to the growth that would have occurred if there had not been an exit announcement of the UK, i.e., 1.86% growth of real wages.

**4.4.3 Consumer Price Index Growth**

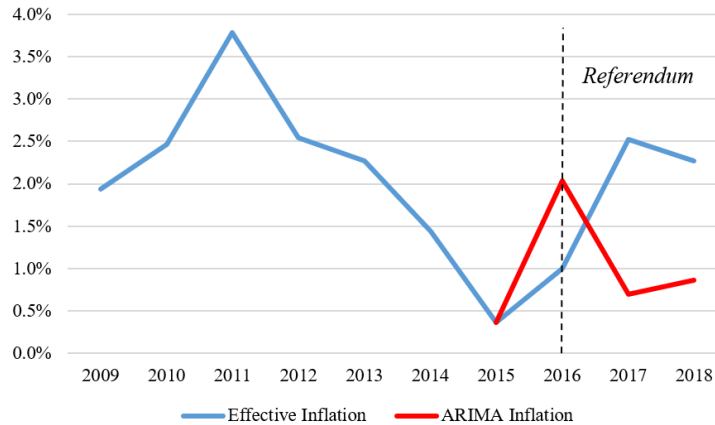
In Table no. 8 and Figure no. 3 is presented the ARIMA forecasts as well as the effective values for the growth of the CPI, henceforth Inflation.

**Table no. 8 – Forecast and effective values of CPI growth**

Year	ARIMA Forecast (No Brexit announcement)	Effective value (With Brexit announcement)
2016	2.036%	1.003%
2017	0.695%	2.526%
2018	0.864%	2.267%

Source: Author’s calculation using Gretl software.

The ARIMA forecast model predicts an increase in inflation of approximately 2% in 2016, and in the following years (2017 and 2018), inflation returns to lower values (0.7% and 0.86%), a contrast to the trend of growing inflation effectively seen on the British economy after 2017. We conclude that, had the UK not announced its intention to leave the EU, its inflation in 2016 would have been higher than that which actually occurred that same year. In the following years, forecasted inflation rates for the scenario of no-Brexit announcement would have been lower when compared to their actual behavior. This leads us to conclude that Brexit had a very negative effect (sharp increase in the CPI growth) practically six months after its announcement.



Source: Author’s calculation using Gretl software.

**Figure no. 3 – CPI growth (%), forecast and effective values**

Regarding our ARIMA model, we suspect that the spike observed in 2016 is related to the characteristics of the sample used to make the forecast, which constantly has inflation rates above 1.5%, with 2015 being the only year in that UK inflation falls below 1%. As the ARIMA model makes predictions based on past information on the variable itself, a high

inflation rate in the past will have an influence on the forecast, which means that the forecast ends up giving little weight to the year of low inflation (out of the ordinary) that it was 2015.

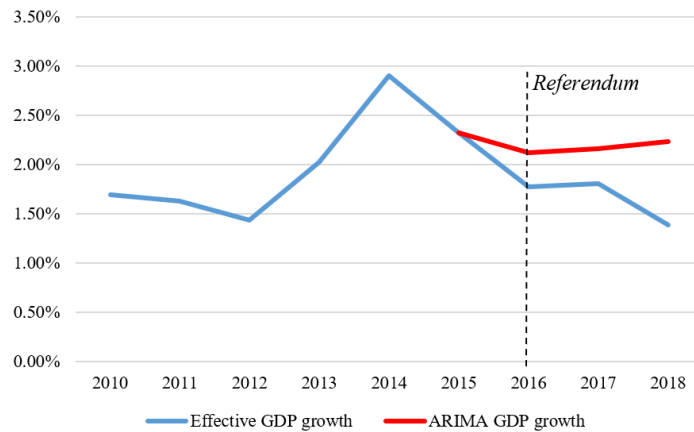
#### 4.4.4 Gross Domestic Product growth

In this last section, we analyze the growth of the UK's Gross Domestic Product. In [Table no. 9](#) and [Figure no. 4](#), we can see the predictions of the ARIMA model and the effective values of this variable.

**Table no. 9 – Forecast and effective values of GDP growth**

Year	ARIMA Forecast (No Brexit announcement)	Effective value (With Brexit announcement)
2016	2.12%	1.77%
2017	2.16%	1.81%
2018	2.24%	1.39%

Source: Author's calculation using Gretl software.



Source: Author's calculation using Gretl software.

**Figure no. 4 – GDP growth (%), forecast and effective values**

In the counterfactual situation of no Brexit announcement, our ARIMA model predicts a GDP growth rate that is permanently above the effective. This leads us to believe that, had there not been a Brexit announcement, the British economy would have grown at a higher pace and with a slight trend of accelerating its growth rate. In this context, we can say that the Brexit announcement had a negative impact on the growth of the GDP. In addition, the gap between the predicted value and the effective value of the GDP growth rate increases over the years. We can then conclude that had there not been a Brexit announcement, this would have reversed, albeit slightly, the negative trend in the UK's GDP growth rate actually registered. In absolute terms, in the counterfactual situation of non-announcement of Brexit, the British GDP would have been 61 billion GBP above the actual situation, i.e., the Brexit announcement caused a breakdown of 3.31% in the GDP, between 2016 and 2018. These values are in line with the values calculated by [Standard & Poor's \(2019\)](#) in a similar approach for 2016 to 2018.

## 5. CONCLUSION

With this paper, we wanted to understand if the announcement of Brexit had a negative impact on the British economy. In our opinion, the long process that started on June 23, 2016 and which is expected to be completed by the end of 2020, had a clear impact on the British economy, and this is proved by the counterfactual analysis that we have done throughout this work.

The exchange rate of the Pound Sterling against the US Dollar was the variable whose effects are most pronounced, with successive depreciations to the point that it almost reached 1 USD = 1 GBP, an historic mark of the British foreign exchange market. The conclusion of this research is that if there had not been a Brexit announcement, the depreciation trend of the Pound Sterling would not have been as expressive as the one that effectively occurred. The value of the British Pound against the US Dollar was, on average, 19% below our forecasts.

Regarding the inflation, our ARIMA model points out to its increase for the first year of analysis (2016), with a subsequent deceleration of the inflation for the years 2017 and 2018. This leads us to conclude that, if Brexit announcement had not taken place, the British economy would have suffered an increase of its general price level with a greater expression in the year 2016 and in the following years, the level of inflation would have not be so high. In fact, between 2016 and 2018, the rate of growth of the CPI increased year by year, which leads us to conclude that the Brexit announcement may have had effects on British inflation with some lag. We believe that this increase in inflation is because of the depreciation of the British pound that rises the prices of imported goods in the UK. Two important notes: the growing inflation trend in the rest of the EU was in line with the British inflation, but below UK inflation levels between 2016 and 2018.

In turn, effective Real Wages in the UK have increased. In fact, growth in Real Wages was higher than the forecast of our ARIMA model, in 2016 and 2017. This leads us to believe that had there not been a Brexit announcement, the increase in real wages would have been smaller in 2016 and 2017, compared to the Brexit announcement scenario. In 2018, the ARIMA model predicts an increase in real wages of 1.86%, when it effectively only increased 0.13%. We concluded then that, had there been no announcement of Brexit, in 2018 Real Wages would have grown more than they effectively did. We believe that the effects of Brexit on real wage growth had a lag due to a certain rigidity of wages. On the other hand, the low level of unemployment and the number of high job vacancies<sup>13</sup> explain the high increase in real wages in the first two years after the UK's exit from the EU.

Finally, our ARIMA model predicts a growth of the GDP above that actually was observed, which leads us to conclude that the Brexit announcement had a negative impact on UK's GDP growth. Also noteworthy is the tendency to decelerate the growth rate of the GDP, which year after year increases its gap to the ARIMA forecast of GDP behavior. We point out as a main explanation for the effective behavior of the GDP a fall in private investment, has firms halted decisions and future planning. In our opinion, the magnitude of the impact of the Brexit announcement was subdued given the domestic demand that remained strong due to growing real wages, a rise in public investment and an increase on the British Current Account balance due to the a rise in exports.

The analysis carried out in this work - the impact of the Brexit announcement -, together with the state of the art of economic literature on the impact that Brexit will have on the British

economy, heralds a not very promising future for the UK. At the time of writing this conclusion, we are yet to know what kind of agreement there will be between the United Kingdom and the European Union. But if the economic literature almost unanimous states that the reposition of borders between the United Kingdom and the European Union will have a negative effect on British economy, with this work we conclude that waiting for the reposition of borders is already having a significant cost on the British economy.

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## Notes

- <sup>1</sup> See [BBC \(2018\)](#).
- <sup>2</sup> See [Independent \(2018\)](#).
- <sup>3</sup> In 1963 and 1967, French president Charles de Gaulle vetoed the UK application to join the European Economic Community.
- <sup>4</sup> Now known as European Union.
- <sup>5</sup> See [Rivera-Batiz and Romer \(1991\)](#) for a general model of gains from integration between countries, [Badinger \(2005\)](#) for the effects of post-war integration between EU countries or [Henrekson et al. \(1997\)](#) for permanent effects on growth resulting from European integration.
- <sup>6</sup> This elasticity measures the change in GDP subject to changes in a country's foreign trade. In this context, for example, an increase of 10% in trade leads to an increase in the product of the same country by 5% to 7.5%. The authors calculates these elasticities by comparing decreasing costs of air transport for goods and comparing with maritime transport, which remain relatively static. Relating who benefited the most from this reduction in transport costs with GDP growth, it is possible to calculate the elasticity of the product in relation to trade.
- <sup>7</sup> See [The Guardian \(2019\)](#).
- <sup>8</sup> See [Washington Post \(2020\)](#).
- <sup>9</sup> See, for example, [Felbermayr and Fuest \(2017\)](#) for an analysis of direct effects or [Kierzenkowski et al. \(2016\)](#) for an analysis of indirect effects of leaving the EU.
- <sup>10</sup> By non-customs barriers, it is assumed that these are any transportation costs, differences in product regulation, legal barriers and other transaction costs other than tariffs paid at customs.
- <sup>11</sup> See again [Rivera-Batiz and Romer \(1991\)](#) on the effects of technological diffusion of economic integration.
- <sup>12</sup> For all AMECO data and variables used in this paper, see [https://ec.europa.eu/economy\\_finance/ameco/user/serie/ResultSerie.cfm](https://ec.europa.eu/economy_finance/ameco/user/serie/ResultSerie.cfm), using the codes XNE, HVGTP, ZCPIN, OVG D.
- <sup>13</sup> See <https://www.gov.uk/government/news/unemployment-rate-lowest-in-over-40-years>.

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