

A Work Project, presented as part of the requirements for the Award of a Master's degree in
Economics from the Nova School of Business and Economics.

ECONOMIC GROWTH IN THE UNITED KINGDOM:
THE IMPACT OF BREXIT

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12/01/2023

Abstract

This thesis analyses Brexit effects on UK economic growth, through the role of internal and external demand. A multiple regression model of UK economic growth was developed, using data from 1997 to 2021. Results from the estimation of the model provided evidence on Brexit's negative impact on internal and external demand. A descriptive analysis of the components of both dimensions accompanied the model and allowed to determine the drivers, connected to Brexit, of the lower UK economic growth. Uncertainty, negative expectations, inflation and trade costs were identified as Brexit related causes of lower economic growth.

Keywords: Brexit, Economic growth, Expenditure approach, GDP, Economic expectations, Uncertainty, Trade costs

Acknowledgements

First and foremost, I would like to thank Prof. Luis Brites Pereira for the orientation and guidance throughout the process of writing this thesis. Also, I would like to acknowledge the support and incentives given by my parents and friends during this process.

This work used infrastructure and resources funded by Fundação para a Ciência e a Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209).

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1. Introduction

In 2016, the United Kingdom (UK) voted in favour of leaving the European Union (EU). By taking this decision the UK left the single market and the customs union on 31 Jan 2020. Subsequently, the UK and the EU signed a limited free trade agreement to govern their future economic relations.

International trade literature highlights the advantages of international trade agreements for economic growth. By lowering trade barriers between countries and other trade obstacles, trade agreements promote economic growth through the expansion of economic activity outside a country's borders. Therefore, in the case of economic integration being reversed, the country should be worse off in economic terms compared to the free-trade situation.

The purpose of this thesis is to analyse the macroeconomic impact of UK's decision to leave the EU. Specifically, the research focuses on the impact on economic growth and its components after the Brexit vote in 2016, through the role of external and internal demand. As such, this thesis aims to answer the following question: What is the overall impact of Brexit on UK's economic growth and its drivers so far? Although Brexit only occurred in January 2020, Brexit effects were felt since the historical referendum. The research will focus on two distinct periods¹: pre-Brexit (from 1997 to 2015), which will be the basis period; and post-Brexit (from 2016 to 2021), corresponding to the period after Brexit vote. These two periods will allow for the detection of Brexit-induced macroeconomic changes. Given the recency of Brexit, relatively limited data is available, thus the analysis will focus on short to medium term effects. The report will start by providing a brief overview of Brexit and a literature review on the subject. The analytical framework in the analysis will be detailed and explained. Finally, the UK macroeconomic context will be addressed through the key variables for economic growth and their determinants. The analysis will be mostly descriptive, though quantitative where

¹ In the trade section, we will include a third period addressing distinguishing pre and post TCA agreement.

possible, allowing for a comprehensive understanding of Brexit impact on economic activity in the UK. Conclusions will be drawn by looking at changes induced by the Brexit vote on the macroeconomic external and internal variables on a 25-year span² (1997-2021). The timeframe allows for comparisons with other economic crises, providing a comprehensive image of Brexit effects. Furthermore, by studying the literature and analysing the econometric model outcomes, the initial hypothesis that Brexit had an overall negative effect on economic growth (both on short and medium term) was condensed.

2. Research Context

2.1. Brexit Overview

Brexit was an exogenous shock to the UK economy, the result of a political decision. The vote for UK to leave the EU was seen at the time as unlikely and no member state had previously left the single market. Thus, Brexit was an unexpected event with unpredictable consequences. Brexit can be considered a unique natural experiment given i) the unpredictability of the result and ii) as the voting behaviour was largely unrelated to UK's recent macroeconomic performance. The negotiation period, from 2016 to 2020, created a tense environment on the UK economy as the UK was at disadvantage towards the EU on the negotiation process. The later represented a larger number of countries and a larger market, leveraging on a high bargaining power. In December 2020, the UK and the EU signed the EU-UK Trade and Cooperation Agreement (TCA), regulating trade relations with the EU member states from January 2021. The expectations were for Brexit to translate into higher costs for trade through increasing red tape and more taxes - any free trade agreement would lead to higher trade costs compared to the Single Market (European Commission, 2021).

² The period will be adapted along the analysis to make more meaningful conclusions, for example for time varying variables shorter time horizons will be addressed.

Brexit coincided with another exogenous shock (covid 19 pandemic), which makes it difficult to separate the respective impacts. Nonetheless, this paper will attempt to separate Covid-19's impact from the one felt by Brexit by adapting the period used and isolating the pandemic effect. The pandemic was a global exogenous shock, felt by all countries, whereas Brexit was a unilateral shock felt on Brexit economy alone. When analysing UK economic growth, the economic context of the EU and US will be used for comparison purposes.

EU-UK Trade and Cooperation agreement

From January 2021, the TCA (a free trade agreement – FTA) guides UK trade relation with the EU. FTA differ greatly in their scope, depth, and effects on trade (Hofman et. al 2017). The TCA allows the UK to have access to the EU goods market with a zero tariff and zero quota trade. However, some regulations need to be followed, comprising additional customs declarations and bureaucracy, which represent higher costs for firms' operations (European Commission, 2021). Being an open economy with comparative advantages in services the UK, under TCA, faces several new challenges connected to the service sector namely the right to establish in the EU, the assessment of professional qualifications, the free flow of data and the movement of people (UK government, 2021).

2.2.Literature review

Historically the UK has benefitted from being an EU member, with increased income levels and higher GDP per capita, which generated economic growth (Nicholas Crafts 2016; Campos et al.2014). These positive effects can be offset by Brexit but it would naive to believe Brexit would produce the exact opposite effects on economic growth. The referendum vote sparked the interest of academics, who reflected on the possible costs and benefits of a “leave” scenario (Baldwin 2016, Van Reenen 2016 and Sampson 2017). Van Reenen study (2016) noticed the expected benefits of Brexit would not offset the downsides, leading to a net loss for the UK economy and to lower economic growth. Sampson paper (2017) points that most literature

agrees on a weaker UK economy over the long-run due to Brexit but the dimension of the loss depends solely on the trade agreement reached between the UK and the EU. Though external demand was initially thought to be the most impacted by Brexit, hampering economic growth through unavoidable increase of trade costs, which lowered trade (Van Reenen, 2016; Bruno et al. 2016), later studies, as the one from Born et al. (2019), added internal demand as also affected with both a decline in investment and consumption. Some papers have indicated that internal investment and productivity have decreased after the vote (Bloom et al., 2019; Hassan et al. 2021), having an impact on economic performance of the UK. Additionally, Breinlich et al.(2022) and Costa et al.(2019) papers refer that the depreciation of the sterling pound induced by the 2016 vote resulted in a higher cost of living and lower real wage growth, contracting consumer spending, and hampering future economic growth. Geiger and Güntner (2022) analysis found evidence that Brexit shocks were drivers of the business cycle after the vote, lowering GDP and consumer confidence. All combined, these effects on the external and internal demand have led to a slowdown in GDP growth (Born et al.2019).

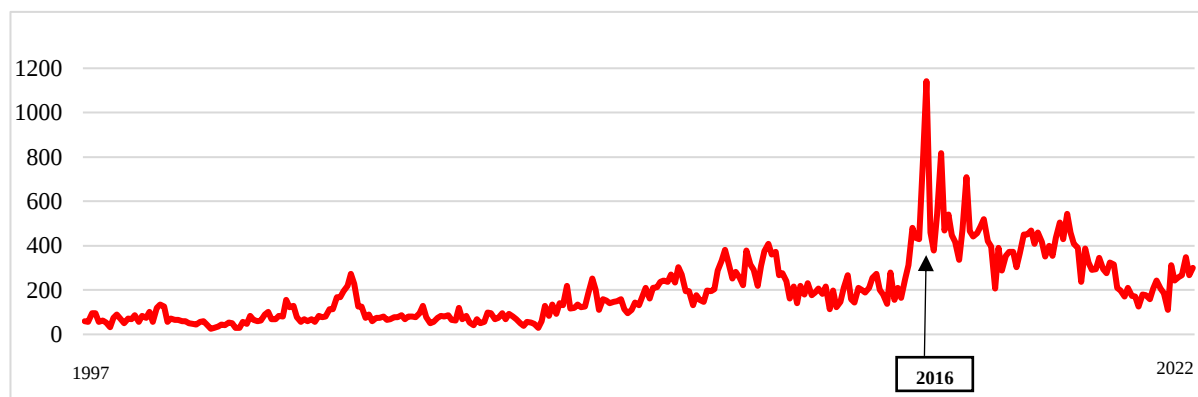
This thesis contributes to recent literature on economic growth, on the drivers of economic growth and on the changes induced by an external shock to the macroeconomic equilibrium of a country. The paper will add to the on-going research on the multi-faceted impact of Brexit on the UK economy. Given that the Brexit transition period ended recently, additional research will be essential to evaluate the long term implications of the UK withdraw from the EU.

2.3. Market reaction and selected macroeconomic variables

In this section, the general market conditions and selected key macroeconomic variables will be addressed. Other macroeconomic variables were also analysed and can be found in the annex I.

Uncertainty and Economic Expectations

The outcome of the referendum generated uncertainty on economic and regulatory policies, and on format of the trade agreement to be reached.



Graph 1: Economic Policy Uncertainty for the UK from 1997 to 2022, monthly data

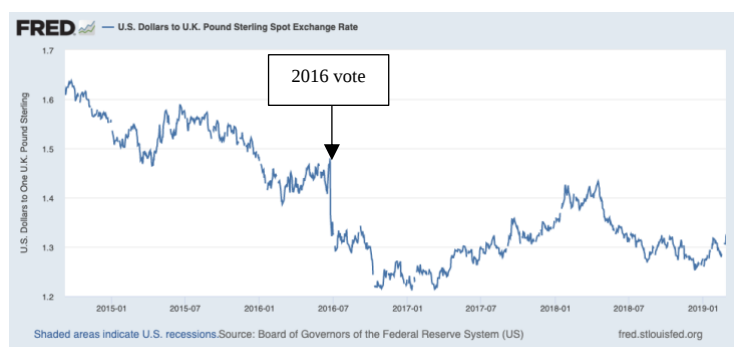
Source: own work using data from Federal Reserve Economic Data – Federal Reserve Bank of St. Louis, last updated sept 2022; <https://fred.stlouisfed.org/series/UKEPUINDXM>

Uncertainty can be measured using the Economic Policy Uncertainty (EPU)³. Graph 1 shows that 2016 had the highest EPU over the past 19 years, implying high economic uncertainty. The following years, corresponding to the Brexit negotiation period, also had a higher-than-average EPU level. The EPU level rose again as the pandemic stroke the economy, but at a lower level than the 2016. Brexit is also in the top three cited sources of uncertainty by firms since 2016 in the Bank's Decision Maker Panel (DMP) Survey. Uncertainty is an important driver of economic agents' behaviour and expectations (DMP Survey 2019⁴). The result of the 2016 vote drove economic agents to a more pessimistic view of the future, weighing on investment and consumption (Bank of England, 2022), constraining economic growth.

³ The EPU is an index constructed based on newspaper articles regarding policy uncertainty from leading newspapers; it counts the number of newspaper articles containing the terms uncertain or uncertainty, economic or economy, and one or more policy-relevant terms.

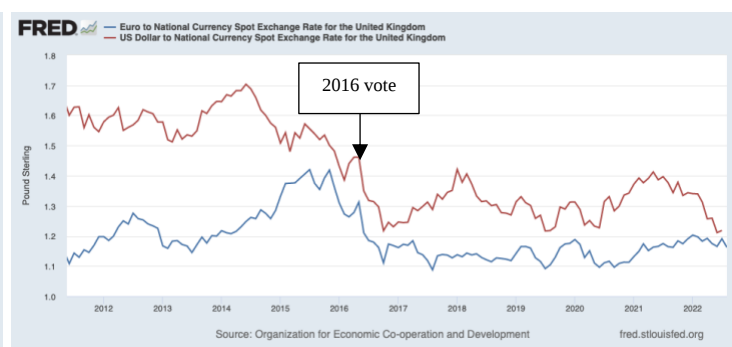
⁴ According to the DMP Survey 2019, firms expected Brexit to have a negative impact on their sales and household expectations have deteriorated since 2019.

Exchange rate



Graph 3: Daily spot exchange rate US dollar \$ against sterling pound £ from 2015 to 2018 (Nominal exchange rate)

Source: Federal Reserve Economic Data – Federal Reserve Bank of St. Louis, last updated Nov 2022



Graph 2: Monthly spot exchange rate US\$/Euro€ against Sterling pound £ from 2012 to 2022 (Nominal exchange rate)

Source: Federal Reserve Economic Data – Federal Reserve Bank of St. Louis, last updated Nov 2022

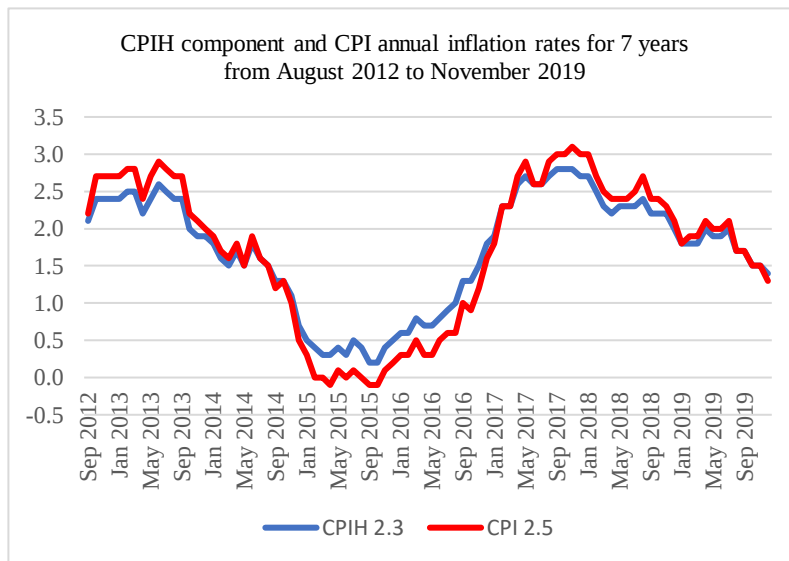
The uncertainty generated by Brexit affected the spot exchange rate of US dollar against the sterling pound and of euro against the sterling pound (Graph 2⁵). The exchange rate level was more sensitive to Brexit related political decisions than to economic performance. Graph 3 shows the sterling depreciated against the dollar about 10% the day after the referendum, which was lower than the one in the wake of 2008 crisis. Investors believed assets denominated in pounds would underperform following the Brexit vote as they anticipated Brexit would weaken the UK economy. Since then, the sterling pound has remained at a low level. The fall in sterling value following the official leave of the UK and the end of the transition period was relatively small, indicating investors' expectations and uncertainty were important drivers in explaining the currency movements (Dornbusch, 1976; Engle and West, 2005).

The real exchange rate followed the same patterns as the nominal exchange rate explained above (annex I). The result from a real exchange rate depreciation is a reduction from the domestic demand side of purchasing power in terms of foreign goods and an increase of purchasing power in terms of domestic goods for foreign economic agents. Over the medium-

⁵ Exchange rates are extremely volatile, as such the use of daily and monthly rates provides the most information on the changes occurred. To prevent the loss of information the time period analyzed is shorter. A nominal exchange rate measures the value of one country's currency in terms of another country's currency. A real exchange rate measures the price of domestic goods in terms of foreign goods.

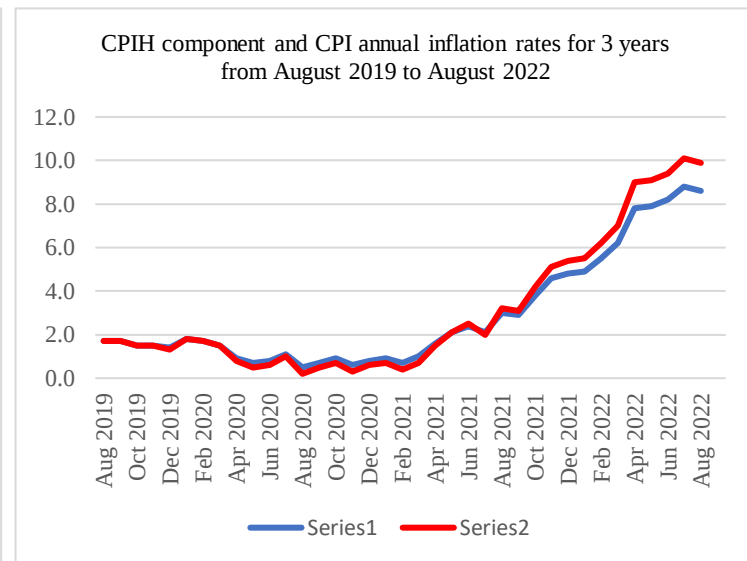
term higher trade costs from leaving the EU may imply the changes of the real exchange rate to be permanent and constitute structural changes. Economic theory explains that an exchange rate depreciation has a direct impact on trade, which will be detailed in the external demand section. Additionally, inflation is likely to occur as explained in the following section.

Inflation



Graph 5 : CPI annual inflation rates for 7 years from August 2012 to November 2019

Source: own work using data from the UK Office for National Statistics;
<https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/consumerpriceinflation/august2022>



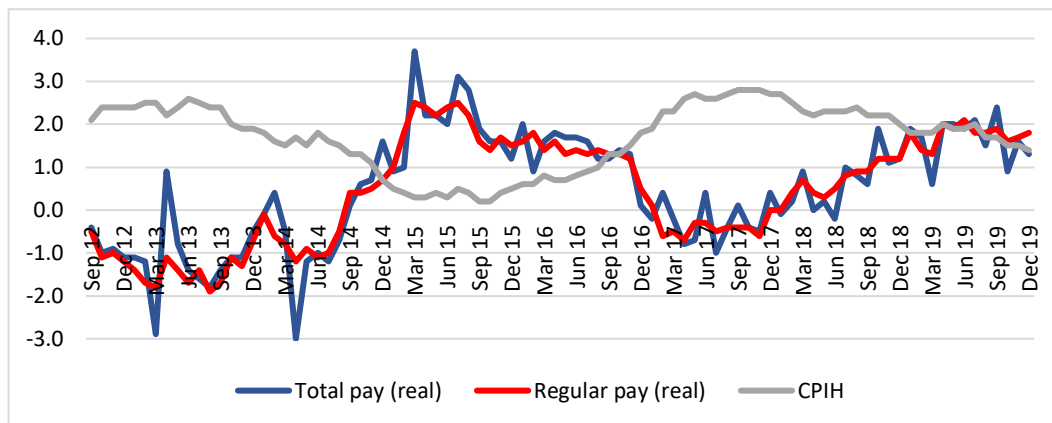
Graph 4: CPI annual inflation rates for 3 years from August 2019 to August 2022

Source: own work using data from the UK Office for National Statistics;
<https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/consumerpriceinflation/august2022>

Economic theory suggests a strong and prolonged depreciation of a country exchange rate is related to an increased inflation rate, by making import cost higher and causing an increase in aggregated demand. In fact, as seen in Graph 5, after the vote for Brexit, the CPI rose from 0.5 percent in June 2016 to 2.6 percent in June 2017 and reached 3 percent in September 2017. The following years CPI levels went down to almost 0.2 percent in August 2020, due to the economic slowdown driven by the pandemic, and back up to 10.1% in July 2022, as shown by Graph 4. The recent increase could be related to the implementation of the TCA agreement, representing higher costs to trade, but other global common factors as increased commodities and energy prices, exacerbated by the Ukrainian war and supply chain disruptions, are

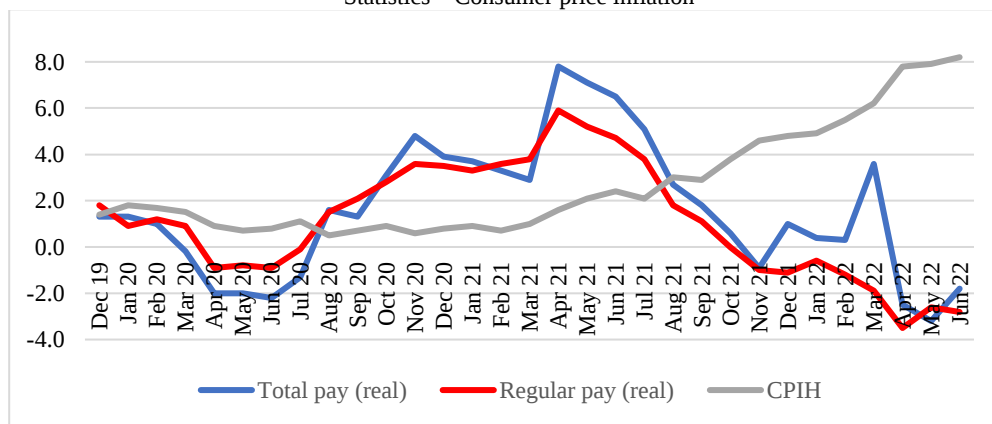
contributing to this phenomenon. Although the increase in inflation cannot entirely be attributed to Brexit, the period in which it started coincides with the Brexit decision. High inflation levels have been noted in other advanced economies; however, CPI for the UK is higher than in EU countries since the referendum (House of Commons Library, 2022). The research by Breinlich et al. (2022) results suggest the 10% depreciation of sterling immediately after the Brexit referendum affected living costs in the United Kingdom, having increased consumer prices by 2.9%. Also, migration flows being limited under new UK regulations coupled with low employment rates pushed firms to pay higher nominal salaries, generating higher inflation (Office for National Statistics, 2022). Higher inflation will reduce real wages if the inflation rate is higher than wage growth, which will be explained below. Thus, inflation will affect real consumption, and, as such economic growth.

Real wages



Graph 6: Real average weekly earnings single-month annual growth rates in Great Britain, seasonally adjusted, from September 2012 to December 2019

Source: own work using data from Office for National Statistics – Monthly Wages and Salaries Survey, Office for National Statistics – Consumer price inflation



Graph 7: Brexit and Pandemic effect on wage growth; real average weekly earnings single month annual growth rates in Great Britain, seasonally adjusted, from December 2019 to June 2022

Source: own work using data from Office for National Statistics – Monthly Wages and Salaries Survey, Office for National Statistics – Consumer price inflation

After the 2008 crisis, real wage growth only resumed by the end 2014 (Graph 6). The 2016 increase of consumer prices (Graph 6) has not been followed by higher real wage growth, mirroring the effects inflicted by the financial crisis. Graph 6 shows that the increase in inflation led to a decrease in real wage growth. The UK wage growth by the end of 2017 was the lowest of the G7 countries since the financial crisis (annex I). Costa et al (2019) research showed real wages had been growing before the 2016 vote, and thereafter stagnated. The paper suggests the effect on wages was higher on sectors connected to trade (both import and export), more

affected by the sterling pound depreciation⁶. The lower real wage growth denoted after Brexit hampered consumption growth. The pandemic had a negative impact on wage growth but this period must be analysed with caution since consumers had access to governmental aids.

3. Analytical Framework

3.1.Theoretical approach

Throughout the report the Keynesian expenditure approach to measure GDP will be adopted. The standard expenditure approach model is useful for assessing the factors and conditions which affect the level of real domestic product (GDP adjusted for inflation). By using the following model to accompany the analysis of economic growth, it will be possible to identify the changing parameters after the Brexit shock:

$$Y = C + G + I + NX$$

Where Y represents the quantity of nominal output of an entire economy (national production, which must be adjusted later for inflation); C denotes private consumption of goods and services; G government spending on goods and services; I investment on capital goods (proxy used: gross fixed capital formation) and NX to the net exports, which corresponds to gross exports subtracted by gross imports ($NX = X - M$). Aggregate output produced by the UK economy can be consumed by internal demand or external demand, thus the analysis of economic growth will be divided by internal demand and external demand. Internal demand is the sum of private consumption, government, and investment, whereas external demand is captured by net exports of goods and services. This model is useful for short-term and medium-term changes in the economy. Economic growth will be the result of an increase in aggregate demand, dependent on internal and external factors. The factors change from the pre-Brexit period to the post-Brexit period will allow to inference the changes to Brexit decision.

⁶ The exchange rate depreciation increased import prices, thus input related production costs rose, constraining the ability for businesses to raise wages.

3.2. Model specification

The variables included in the model will be analysed in real terms, that is at 2015 prices and transformed into logarithmic terms (denoted using the prefix L). Using the levels at 2015 prices will provide us information of Brexit impact to the real economy. The paper will use time-series yearly data retrieved from the World Development Indicators database, for the years 1996-2021. The following multiple factor regression model⁷ was constructed:

$$L(Y_t) = a_0 + b_0L(C_t) + b_1L(G_t) + b_2L(I_t) + b_3L(X_t) - b_4L(M_t) + \varepsilon_t$$

After conducting the necessary tests statistics, the model was adapted to follow the Gauss-Markov assumptions and for the series to be stationary (annex II). The variables were applied first-differences⁸ and aggregated to two categories: internal and external demand. The log difference of a particular variable can be seen as the growth rate of the addressed variable.

The estimated model is the following:

$$d_{L(Y_t)} = a_0 + b_0d_{L(Int)} + b_1d_{L(Ext)} + \delta_t + \varepsilon_t$$

Where $d_{L(Y_t)}$ is the first difference of the log of GDP in real terms; $d_{L(Int)}$ is the first difference of the log of Internal Demand in real terms; $d_{L(Ext)}$ is the first difference of the log of External Demand in real terms. A time dummy δ_t was added identifying the years in which an economic crisis happened to control for outliers within the data (2008 crisis and pandemic). This model allows to estimate a direct contribution of the movement (growth rate) of each dimension (internal or external) to the growth rate of real GDP of the UK economy, identifying which is more significant to economic growth for the UK, through time. The model will indicate the structure of economic growth.

⁷ The constant corresponds to the average influence of all factors which are not included in research.

⁸ By applying the FD to the variables, we lose one observation for each variable (the one related to 1997), we have a degree of loss of information.

3.3. Empirical Results

We will have three models⁹, estimated through OLS, corresponding to different time sections:

- Pre-Brexit model (basis): using data from 1998-2015
- Post-Brexit model: using data from 1998-2018
- Post-Brexit/ pandemic/ TCA implementation: using data from 1998-2021

Table 1: Estimation results using OLS for adjusted version

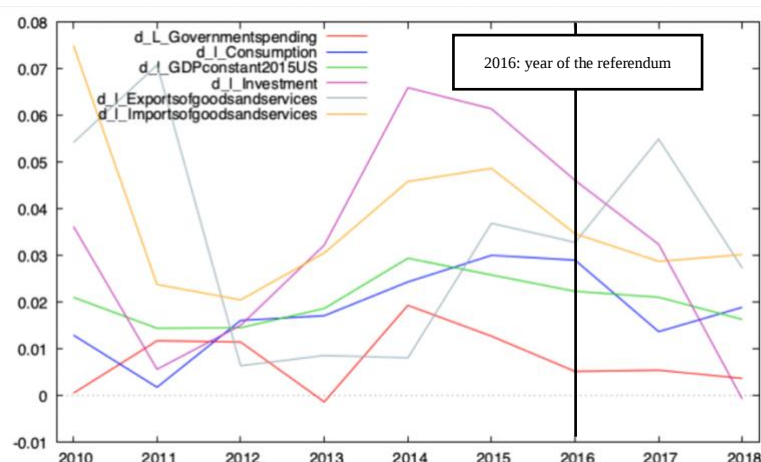
	Pre-Brexit	Post-Brexit	Post-Brexit/Pandemic/TCA
	1998-2015	1998-2018	1998-2021
Constant	-0.0018	-0.0014	-0.0011
Internal Demand	1.0614***	1.0456***	1.0161***
External demand	0.4467***	0.4466***	0.4400***
Crises dummy	-0.0054	-0.0058	-0.0066

The *** indicate the variables are significant at 1%, 5% and 10% significance level.

In all models, both internal and external demand are significant explanatory variables to explain economic growth (Table 1). However, the contribution of internal demand was the most significant over the analyzed periods. We assume if no vote had occurred the trading relationship between the EU and the UK would not have changed and there would be no uncertainty in the environment. As such, the estimation forecast would be similar to the model from 1999 to 2015. Thus, the comparison between model 1 and model 2 will give us the change inflicted upon the UK economy by the Brexit vote. From model 1 to model 2, there was little change to the contribution of external demand to economic growth. Whereas internal demand suffered a 0.024 percentage point change in its contribution to economic growth. From model 2 to model 3, there was the implementation of the TCA agreement and the effect of the pandemic. The effect of the pandemic is at some degree controlled for with the time dummy, however not fully. External demand contribution to economic growth, which previously was

⁹ The purpose of having three models is to have the full impact of the Brexit decision, trying to isolate pandemic related effects.

unaffected, also decreased (by 0.0066pp). Internal demand contribution to economic growth decreased further, by 0.0295 pp.



Graph 8: Representation of the independent variables, without the outliers

Graph 8 shows the response of the components to the referendum, excluding the pandemic and TCA implementation effect. Consumption growth reacted promptly as did the export growth. Investment growth plummeted from 2015 onwards. Government spending was almost stagnant in terms of variation. Imports growth stagnated. As an attempt to determine where the changes to internal and external demand came from, the models estimated previously were once again estimated using instrumental variables. The construction and results of the models are explained in detail on the annex II. The following post-Brexit trends were identified: Consumption was sustaining economic growth while investment and government decreased its contribution to economic growth; Exports growth contributed more to economic growth, while imports restricted it.

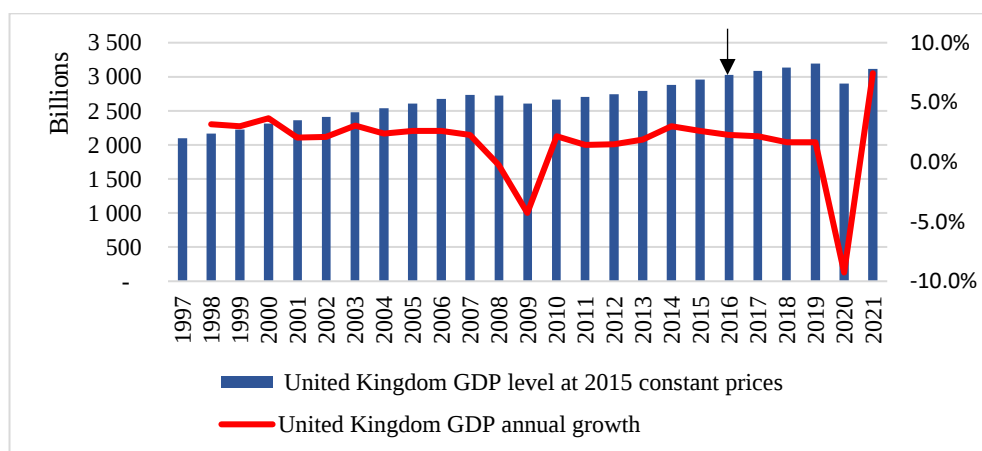
3.4. Summary of model results

Internal demand is the most important component when explaining economic growth. After the Brexit vote, its contribution to economic growth was reduced through investment channel and possibly government spending channel. External demand is important to explain economic growth but at a lower degree than internal demand. It was after the TCA implementation that external demand contribution to economic growth was reduced through the import channel.

Thus, the TCA effect on external demand reinforced the effect of the Brexit vote on internal demand.

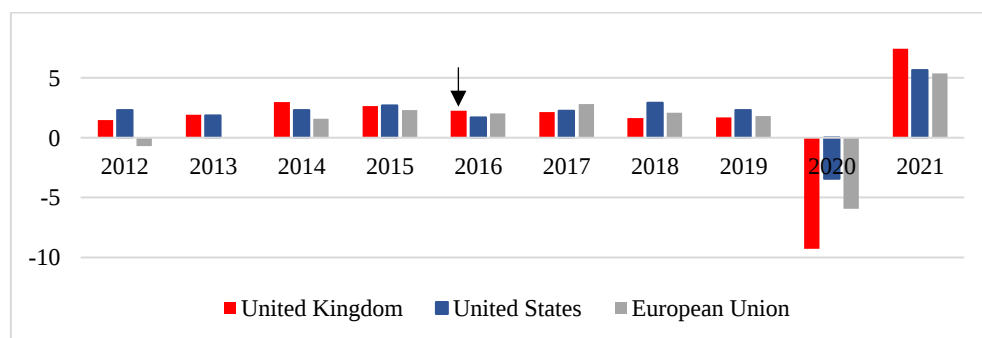
4. Economic growth

Looking at Graph 9, UK real GDP level over time suffered two negative shocks: the 2008 financial crisis and the pandemic. After the 2008 crisis recovery, from 2015 onwards, lower economic growth rates can be noted, corresponding to the announcement of the Brexit vote and its result.



Graph 9: UK annual GDP (constant 2015 US\$) and annual growth rate from 1997 to 2021

Source: Own work using the data from World Development Indicators



Graph 10: Gross domestic product annual real growth for 10 years (from 2012 to 2021) for the UK, EU and USA¹⁰

Source: own work using data from World Development Indicators

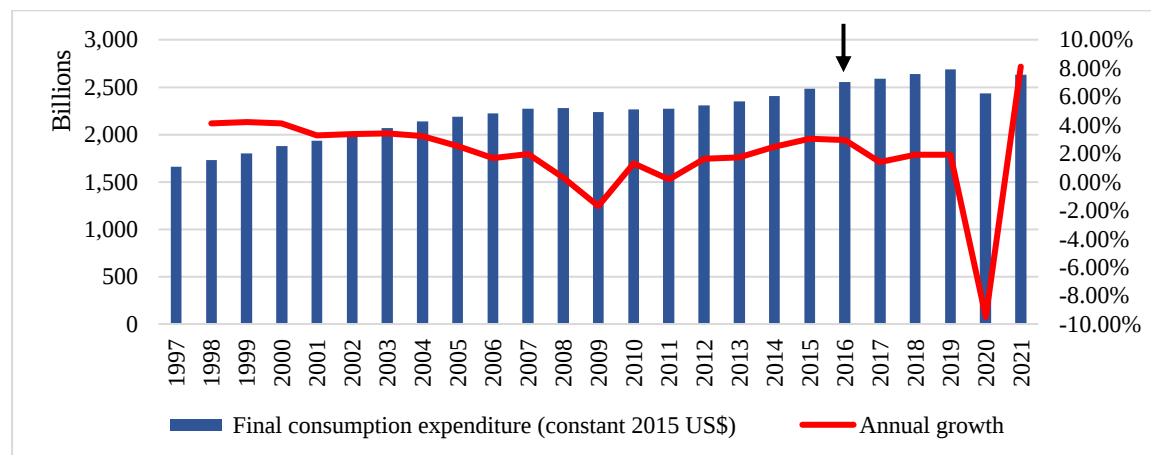
¹⁰ The UK was part of the EU, as such its economic performance should follow more or less the trends of the EU average. Thus, the comparison is meaningful. It must be noted in 2013 the EU had an almost null growth, as such the scale used neglects any change.

Since 2012, the UK GDP growth rate was above the EU average. Graph 10 shows, in 2016, the gap between EU and UK GDP growth decreased, a shift in growth trends. From 2017 until 2020, the UK had a slower economic growth than the EU and the US, which can reflect the effect of Brexit uncertainty on the country economic performance. In the year the pandemic hit, the UK recorded a negative GDP growth. The lifting of Covid-19 restrictions allowed the UK economy to surpass the EU in terms of GDP growth. The success of UK vaccination campaign led to an open-up of the economy earlier than other advanced economies. In terms of GDP levels, the UK should have recovered more rapidly than other G7 economies, which was not the case (House of commons Library, 2022; annex I). Other shocks specifically to the UK economy explain the post-pandemic slower recovery, possibly Brexit.

4.1. Contribution of Internal Demand

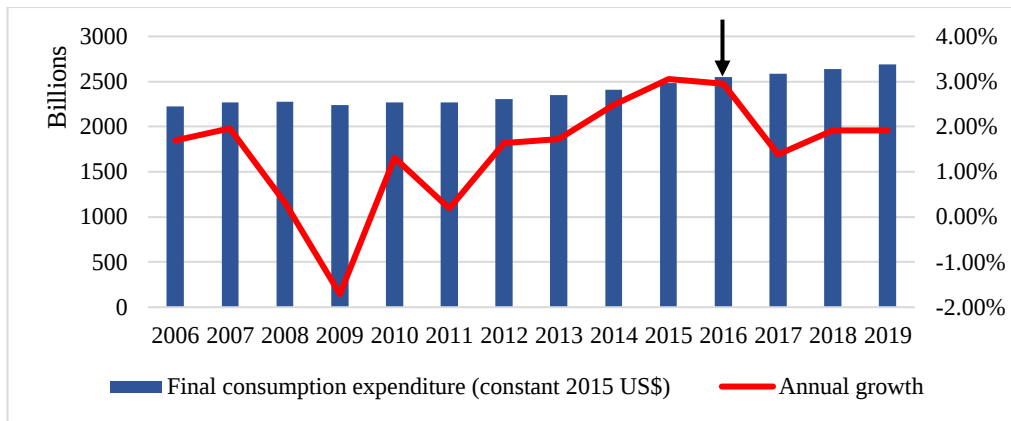
In this section, the components of internal demand will be analysed to determine the source of the fall of the contribution of internal demand to economic growth.

Consumption



Graph 11: Final consumption expenditure in the UK from 1997 to 2021 (at constant 2015 US\$)

Source: own work using data from World Development indicators



Graph 12: Final consumption expenditure in the UK from 2006 to 2019, in real level and annual growth

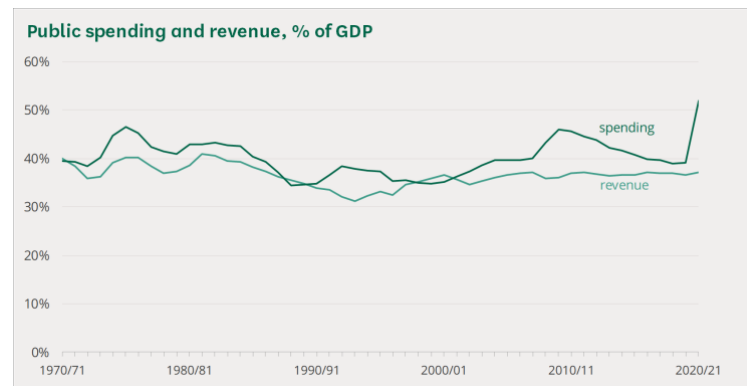
Source: own work using data from World Development Indicators

Comparing Graph 11 with Graph 9, it stands out consumption growth follows the same trends as economic growth, with consumption growth seemingly having been sustaining economic growth in the UK¹¹. Graph 11 shows that the referendum had similarly no impact on consumption expenditure, in contrast to the 2008 crisis and the pandemic; but consumption growth did become stagnant. According to Imanol Alvarez (2019), the Brexit result led, by the end of 2017, to a loss of consumption of 18.79 billion dollars, in 2018 to a loss of 43.191 billion of dollars, reducing significantly economic growth. Consumption patterns altered because consumer expectation about their future income changed with the referendum result. As seen previously, consumers believed Brexit would have a negative effect on the economy. These expectations were self-fulfilling as Brexit increased inflation through the sterling depreciation (Breinlich et al.) and resulted on a lower real wage growth. The lower real wage growth slowed consumption. According to OECD data, the 2016 vote decreased household disposable income by 0.3% (annex I), through the inflation generated by uncertainty. The lower household disposable income effect is also apparent in the savings panorama: in 2016, UK households saved less 3% than in the previous year (annex I), reaching an historically low household saving rate. The Brexit vote had no impact on households' behaviour to contract debt, as the level was

¹¹ As the IV estimation results suggest (see annex)

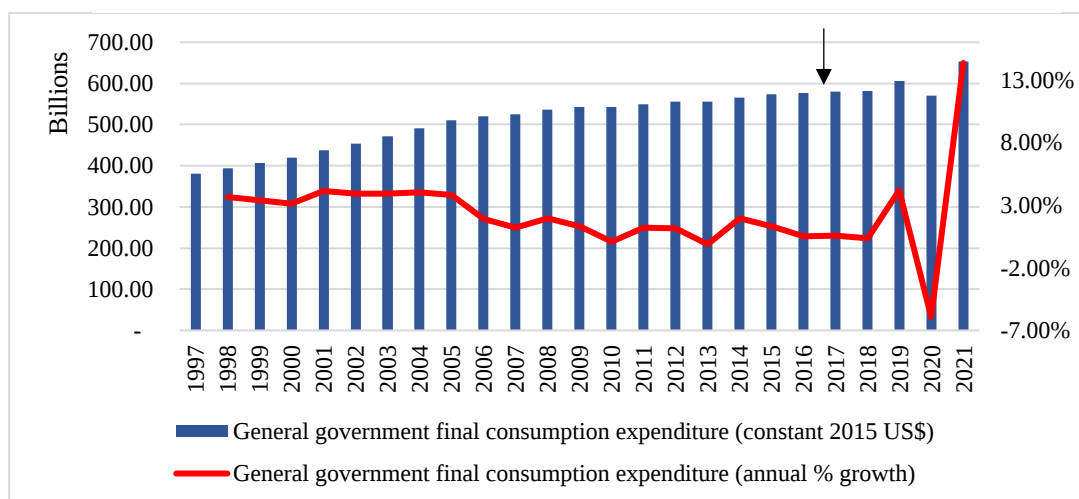
maintained through lower interest rates, a decision implemented by the Bank of England (annex II).

Government spending



Graph 13: Total government spending and revenue to GDP, from 1970 to 2021

Source: House of Commons Library, 2022



Graph 14: UK real government spending from 1997 to 2021

Source: Own work using data form World Development Indicators

As denoted by Graph 13, since the 2008 crisis and even through 2016 voting, UK's government spending to GDP followed a downward trend, consistent with the austerity measures adopted after the financial crisis. Imanol Alvarez (2019) research found a widening gap from 2015 until 2018 between the actual spending of the government and a created counterfactual, where actual government expenditure was lower, denoting a slowing down of public expenditure. The pandemic increased substantially government spending: from 2019 to 2020 government spending increased by 12% of GDP, especially through the healthcare system and aid to sustain

economic activity. Despite the year of 2020, government spending has consistently been around 35% to 45% of GDP. The UK government report (2018) provides information on why government expenditures slowed down after the 2016 vote (Graph 14): decrease of tax revenues prospects for the future following inflationary pressures created by uncertainty and the depreciation of the pound. Indeed, after the 2016 vote onwards, the government annual tax collection slowed down(annex I). The largest tax collection comes from income tax (Commons Library Research Briefing, August 2022), thus the lower real wage growth contributed to the slowdown of tax revenues.

After the 2016 vote, the government made important changes to the government budget, decreasing available resources for government spending. These changes included a £3billion contingency fund in the 2017-2018 Budget for the transitional period and the creation of two new department¹²s to help with Brexit related transition changes. The fund purpose was to counterbalance any short-term effects of Brexit.

The UK was a net contributor to the EU. The direct effect of leaving the EU is the end of contributions to the EU budget, although, the UK would also lose access to EU spending. During the period being analysed, the UK agreed to continue the contribution to the EU budget, thus the effect on government expenditure will be felt only in the future.

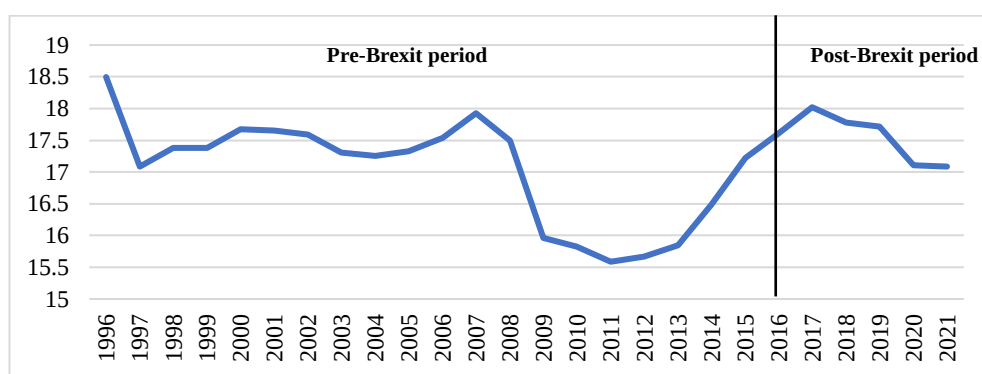
Spending has consistently been higher than revenues, which means public finances are incurring in budget deficits (Graph 13) and need to be financed. According to the House of commons, the budget deficit average is 3.6% of GDP, besides periods of economic crisis. In the year of the Brexit vote, the country also incurred on a budget deficit but lower than average. However, pre-Brexit forecasts expected a “close down” of the deficit (Treasury, 2015), thus the Brexit result led to unexpected increase in borrowing needs¹³.

¹² The two new departments are: Department for Exiting the European Union and the Department for International Trade

¹³ Springford study (2019) estimated a referendum related cost levelling up to a weekly 320 million pounds for the Treasury.

In terms of debt, Brexit seems to have no direct impact on government debt within the period analysed (annex I), but the uncertainty generated by the vote result had an impact on the associated costs of debt. Samir Kadiric (2022) showed the significant impact of Brexit on yield spreads resulting in higher sovereign risk in the UK. The rise in risk premium may cause government bond yields to increase and the need for tighter fiscal discipline, therefore making it harder to deal with Brexit effects to the economy.

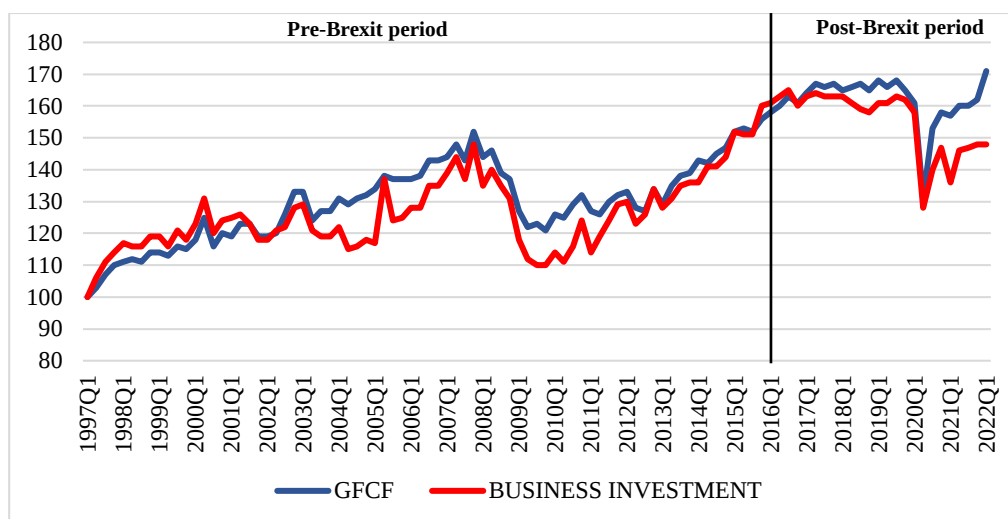
Investment



Graph 15: Annual gross fixed capital formation (GFCF) as a percentage of GDP from 1996 to 2021

Source: own work using data from World Development indicators

Graph 15 shows, before the Brexit vote, investment was starting to recover from the 2008 shock. From 2013 to 2015, gross fixed capital formation (GFCF) in terms of GDP increased 1.34 percentage points (in two years). After the 2016 vote, GFCF stagnated with a 0.4 pp increase from 2016 to 2017 (and from 2017 to 2018). Domestic investment was still growing but at a lower rate. Furthermore, the pandemic shock decreased investment. According to the Bank of Spain (2018), the slowdown in investment post-Brexit is explained by the slowdown in business investment, as residential investment kept growing consistently in the three years post-referendum and public investment was rebooting.



Graph 16: UK real business investment in quarters from 1997 to 2022, chained volume, seasonally adjusted

Source: own work using data from Office of National Statistics, 2022

Graph 16 shows the stagnation of business investment post-Brexit. An IMF working paper (2018) identified the business investment growth rate as “*half the rate that applied before the global financial crisis*”. The UK business investment growth rate lowered when other similar developed economies (G7 countries) had strong business investment growth, implying specific UK characteristics were driving this slowdown (IMF working paper, 2018). The lower rates of investment post-referendum can be explained by uncertainty, having affected business ‘expectations about the future negatively, depressed actual investment (Bank of England, 2019). The IMF working paper and DMP Survey (2018)¹⁴ suggested uncertainty, expectations of future trade costs and bureaucracy drove the negative impact on firm investment in the UK post-referendum. Throughout the negotiation period there was uncertainty about the form taken by Brexit and how the UK relationship with other countries would be regulated, which led businesses to postpone and even cancel investments within the UK. The future increase in trade costs decreased the incentives to invest (Bank of Spain, 2018). Additionally, the sterling pound depreciation increased the cost of capital for firms importing inputs.

¹⁴ In the Decision Maker Panel Survey (2018) concerns about Brexit and the possibility of trade frictions were mentioned as reason to postpone investment or even divert it to other countries. Additionally, the results from this survey show businesses linked to higher levels of Brexit uncertainty experienced lower growth in investment since the referendum.

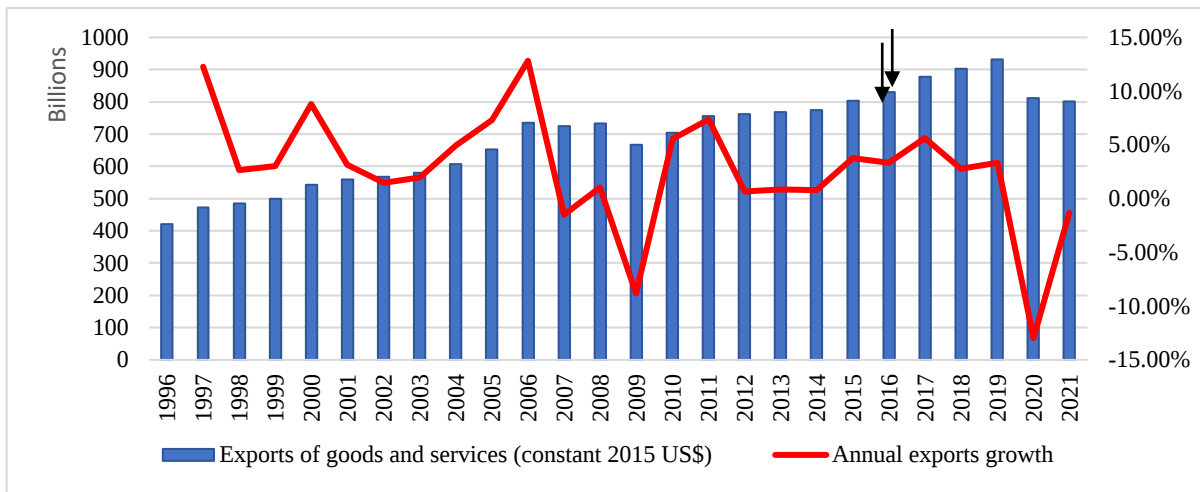
Conclusion – Internal Factors

Overall, in the short-term, Brexit had a negative impact on internal demand contribution to economic growth. All the components of internal demand have been negatively affected by Brexit. Consumption, investment, and government spending slowed down after the Brexit vote. The changes in the components derive from the economic agents' negative expectations about the future of UK economic activity and the uncertainty about trade regulation. The negative expectations generated the depreciation of the pound and the inflation, which hampered wages prospects, business costs and tax collection prospects. In the medium term, the recovery of internal demand is subject to challenges connected to inflation, leading to higher costs of living, and costs associated to trade contracting business' ability to invest. However, in the medium to longer term, the government will cease its financial responsibilities towards the EU, which could allow to ease some internal consequences of Brexit. Any savings from direct contributions to the EU budget could be offset by the lower GDP growth.

4.2. Contribution of External demand

In this section, the components of external demand will be analysed to determine the source of the variations of external demand contribution to economic growth. During the transition period the UK remained in the single market and customs union. The TCA agreement only came into effect in January 2021.

Overall Trade

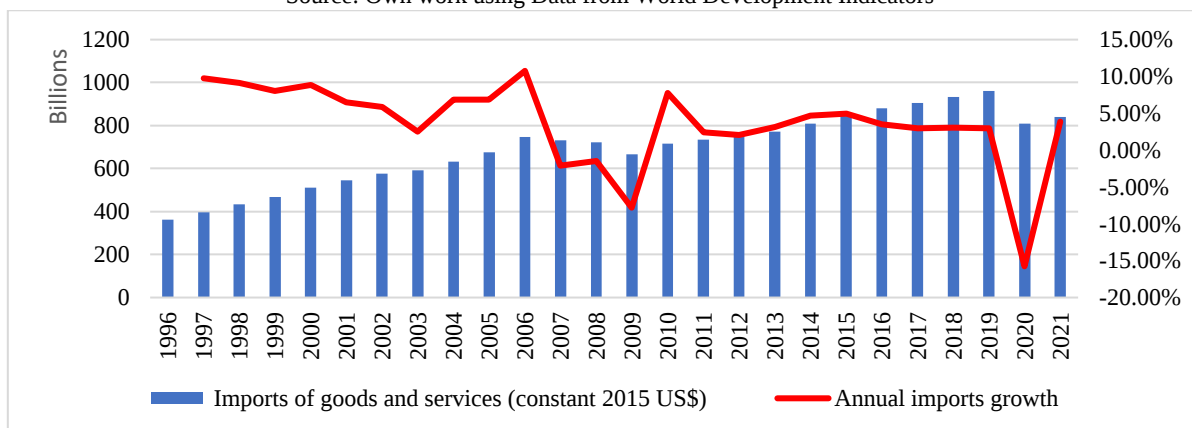


Graph 18: Exports of Goods and Services from 1996 to 2021 (real value)

Source: Own work using data from World Development Indicators

Graph 17 : Imports of Goods and Services from 1996 to 2021 (real value)

Source: Own work using Data from World Development Indicators



Graph 17 and Graph 18 show after the 2008 crisis, real exports and imports of goods and services (G&S) rebounded quickly. However, right before 2016, exports had an almost null annual growth and imports denoted a lower annual growth. After the referendum, annual exports growth increased in 2017 by 5.65% (Graph 17). The increase in real exports of G&S materialized along with the depreciation of the sterling pound, created by uncertainty and negative expectations. The change in annual export growth trend could potentially be due to the gain of competitive advantage in foreign markets by UK firms as UK exports become cheaper with a weaker pound. Imports after 2016 denoted a weaker annual growth decreasing about 2 pp from 2015 to 2017 (Graph 18). The depreciation of the sterling pound made imports

more expensive for UK firms. Economic theory suggests the depreciation of the exchange rate has had direct impact on trade: exports became cheaper, and imports became expensive¹⁵; leading to a lower trade deficit in the years after the vote (annex I) and improving the current account balance (annex I). An important effect of higher import prices was appointed by the findings of Costa et al. (2019)¹⁶: the higher input import prices affected wage growth negatively, thus affecting consumption. Some studies found these effects on trade to be negligible and found no signs of trade frictions due to uncertainty and expectations (Imanol Alvarez 2019; Freeman et al 2022), thus the interpretation results must be taken with some caution. The pandemic decreased substantially both UK imports and exports (Graph 17 and 18), and the levels have not recovered yet to pre-pandemic levels. The recovery may take longer due to pandemic related rigidities (example: supply chains disruption) but also, up to a certain level, to the implementation of the TCA.

According to Ezeani (2018), the EU and the UK both benefited from their trade relationship: the EU had access to services imports from the UK, whereas the UK benefitted from good imports from the EU. Thus, the following subsections will address trade in services and goods independently.

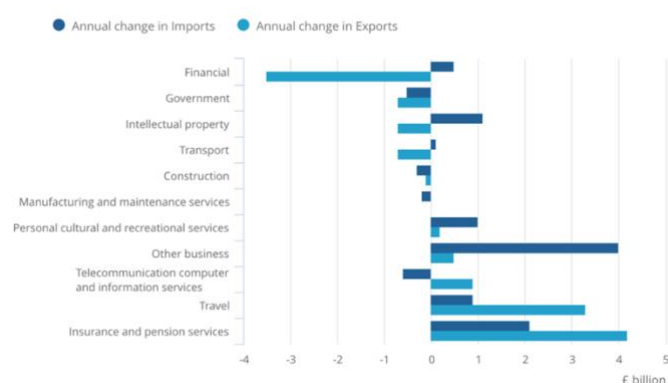
¹⁵ These tendencies are translated in both goods and services trade independently: exports of goods annual growth rate increased from 0.74% in 2016 to 7.55% in 2017; imports of goods annual growth rate decreased from 3.7% in 2016 to 0.1% in 2018; goods trade deficit lowered; exports of services annual growth increased from 5.91% in 2016 to 6.7% in 2017; imports of services annual growth decreased to almost half from 2015 to 2016; services trade surplus increased in 2017 and 2018 compared to 2016.

¹⁶ Costa et al. (2019): “Both training and hourly wages fell for workers employed in sectors where intermediate import prices rose by more due to the sterling depreciation.”

Trade in services

Figure 7: Financial services saw the largest fall in exports in 2021

Contributions to the annual change in the trade in services, by service type, 2020 to 2021

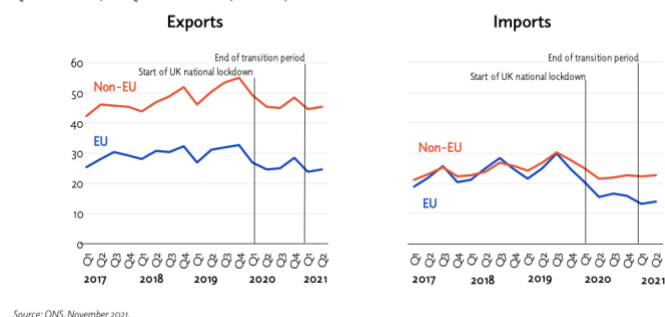


Graph 19: Contribution to the annual change in trade in services, by service type from 2020 to 2021

Source: The Pink Book 2022

UK service exports and imports have decreased since 2019 to both EU and non-EU countries.

Figure 3: UK exports and imports of services to EU and non-EU countries, Quarter 1 2017 to Quarter 2 2021 (£ billion).



Graph 20: UK services exports and imports to EU and non-EU countries, in quarters from 2017 to 2021

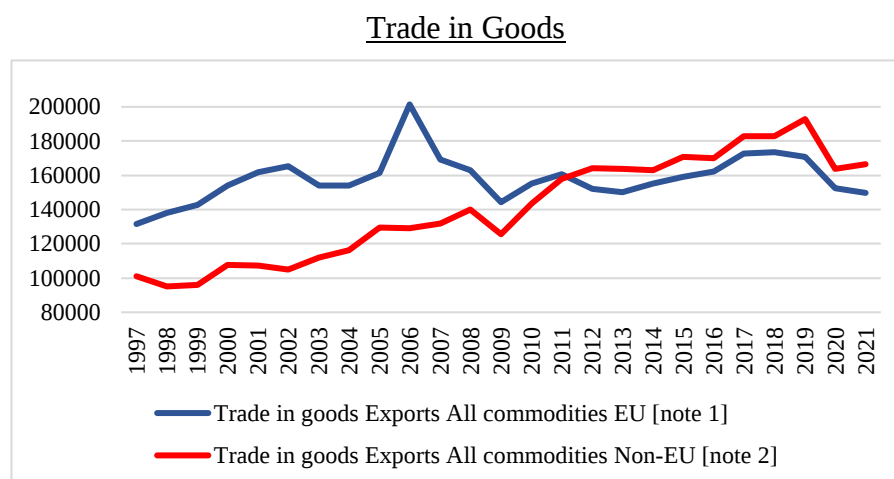
Source: UK in a Changing Europe, *The impact of Brexit on UK services*, 2021

The UK has strong comparative advantages in services trade, especially in financial services (Allas et al 2019). According to OECD (2021), UK trade in services depends heavily on final demand of the EU, thus a new regulatory framework to dwell with this trade relationship will affect service trade. The FTA translates into an increase in non-tariff barriers (NTB)¹⁷ between the EU and the UK. NTB affect the ability and willingness of businesses to trade; and this type of barriers weights more heavily on trade in services¹⁸ (HM Government, 2018). Financial services exports were the most impacted by the TCA implementation with a fall in 2021 of nearly 4% compared to 2020 (Graph 19). This type of service does not involve physical movement of people and can be done remotely, thus other factors than the pandemic led to this fall (The Pink Book, 2022). The fall in financial services exports can be attributed to the increase in NTB from the TCA implementation. As shown in Graph 20 and in annex I, imports increased more than exports which led to an overall lower trade surplus in services in 2021. Graph 24 shows the pandemic impact on services trade was different to EU and Non-EU

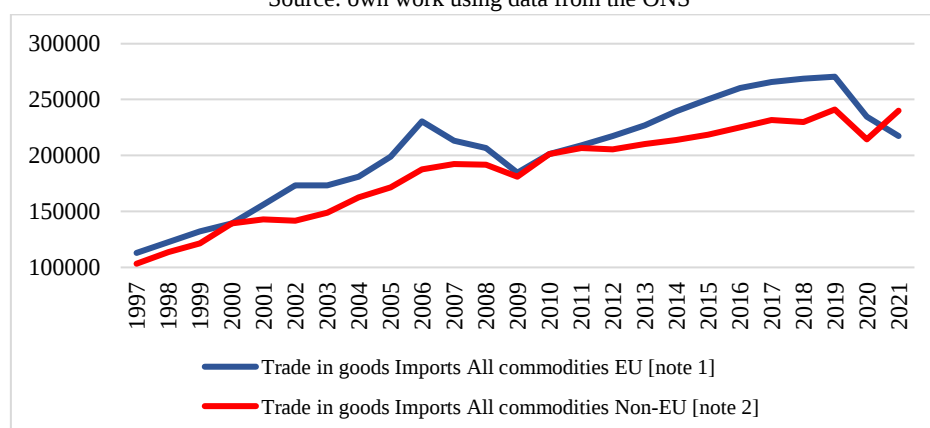
¹⁷ NTB have been decreasing within the EU single market, by leaving the EU the UK will not take advantage of the integration process (Szczepański, 2017)

¹⁸ Under the TCA, financial services, air and road services see their operations with a challenge as they lose their passporting rights to other EU economies.

countries: there was a larger impact on EU trade than in non-EU trade from the UK, suggesting Brexit is playing a role. UK service exports to the EU were 20.3 % lower from 2019 to 2021, compared to a 10.5% lower UK service exports to non-EU over the same period. Additionally, it is visible a shift away EU imports to non-EU imports consistent with the increasing in trade costs caused by the TCA agreement.



Graph 21: Exports of goods from the EU and the Rest of the world (in million of sterling pound £)
Source: own work using data from the ONS



Graph 22: Imports of goods from the EU and the Rest of the world (in millions of sterling pound £)

Source: Own work using data from ONS

In Graph 21, UK exports of goods since 2010 are higher for non-EU countries; but the gap in the value of exports to the non-EU vs to the EU widened from 2016 onwards and worsened with the pandemic. After the pandemic and TCA implementation, UK exports of goods to the EU have not picked up in the same way as UK export to the non-EU (Graph 21). According to Freeman et al (2022), this fact is explained by the increase in fixed costs of exporting to the

EU, leading smaller businesses to exit the EU market.¹⁹ The overall export dynamic was not as severely impacted, because larger firms have absorbed the additional fixed costs. Graph 22 shows UK imports of goods was EU oriented from 1997 until 2020, despite the 2008 crisis and the pandemic. However, in 2021, when the TCA agreement was implemented, imports of goods from the UK have diverted from the EU to being provided by non-EU countries. According to Freeman et al. (2022), UK imports from the EU declined about 25% more than UK imports from non-EU countries, after the TCA implementation.

Conclusion – External factors

External demand contribution to economic growth was unaltered after the Brexit vote, through the depreciation of the pound. Brexit news improved the trade deficit as exports growth was driven by devaluation of the pound against other currencies and imports growth slowed. Unfortunately, this first impact was temporary as the economy adjusted to the news and generated further rigidities to economic growth (inflation). After the implementation of the TCA, external demand contribution to economic growth reduced, as frictions and additional costs to trade introduced structural changes to the economic framework. Trade was reduced between the EU and the UK, which reduced the ability of the UK to specialize according to its comparative advantage leading to a loss in productivity and reducing the market served by UK goods and services, contracting economic growth over the medium to long-term.

Conclusion and research agenda

Brexit was an act of self-harm, as it was an internal decision affecting all the dimensions of economic growth negatively. Overall Brexit had a negative effect on aggregate demand, affecting negatively both internal and external demand contribution to economic growth. The model indicated investment as being the main channel which the contribution to economic

¹⁹ A report by the Department for Business Innovation & Skills of the British government showed from 8% of Small and Medium Enterprises (SMEs) exporting goods and services, 82% exported to the European Union; and have been affected by the implementation of the TCA.

growth by internal demand was reduced, but after taking a closer look at all the components of internal demand, we can say all have been negatively affected by Brexit as they all denoted lower growth rates. After implementing the TCA agreement, external demand contribution to economic growth was reduced through the import channel. The change in trends for the components were initially driven by the negative expectations about the future of UK economic activity and the uncertainty about trade regulation. The negative expectations generated the depreciation of the pound and the inflation, which hampered wages prospects, business costs, tax collection prospects and import prices. The TCA agreement introduced frictions and additional costs to trade, which constituted structural changes to the UK economic scenario and added to inflation. In the medium term, the recovery of internal demand contribution to economic growth is subject to challenges connected to inflation, leading to higher costs of living, and costs associated to trade contracting business' ability to invest. Additionally, the reduction of trade between EU and UK will reduce the ability of the UK to specialise according to its comparative advantage leading to a loss in productivity and reducing the market served by UK goods and services, contracting economic growth over the medium-term.

Due to time and space limitations, further research is needed to depict the full scope of Brexit effects to the UK economy. I had to find the balance of descriptive and empirical analysis which left some subjects to be developed in the future. I would like to have studied the causes of inflation more exhaustively to have more evidence that part of inflation was Brexit induced. The effects of Brexit on productivity should be investigated and looked at with more detail. Additionally, the recency of the event limits the view of all the effects, thus the need for further research. Also, in what concerns the model, the use of IV did not lead to significant results, thus the use of other possible IV could be fruitful. To better distinguish the pandemic effects

from the Brexit effects, creating forecasts or even a doppelganger²⁰ could be the answer, but due to time restrictions these options were left to be used.

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²⁰ The doppelganger consists of creating a similar pattern for economic growth using the behavior of other countries, which were impacted by the pandemic but not by Brexit.

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Annex I: Description of all macroeconomic variables

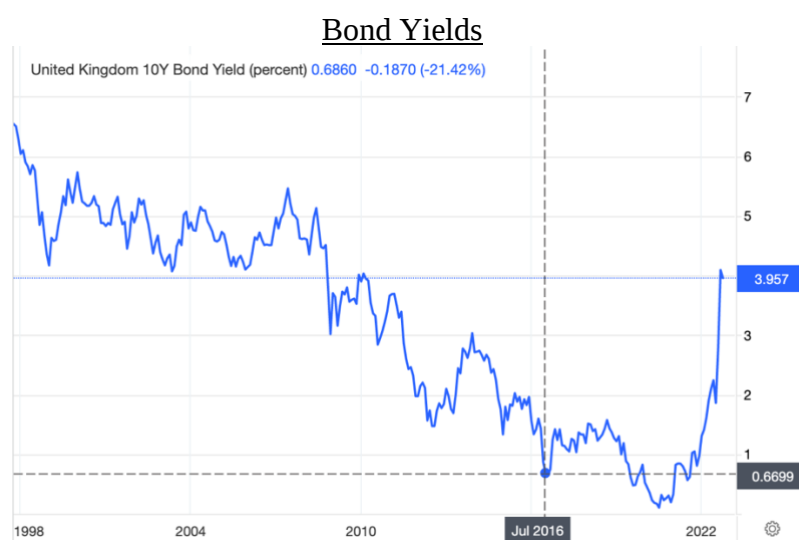
Economic Policy Uncertainty

The EPU is an index constructed based on newspaper articles regarding policy uncertainty from leading newspapers; it counts the number of newspaper articles containing the terms uncertain or uncertainty, economic or economy, and one or more policy-relevant terms.

The uncertainty surrounding the Brexit process surged throughout the negotiation period, where it was unknown the role which the EU and UK relations would take, it could take a softer or harder form of Brexit. Dhingra and Sampson (2016) outline three alternatives for the UK post-Brexit: remain within the Single Market (ex: Norway); negotiate bilateral trade deals with the EU (ex: Switzerland and Canada); or trade with the EU under World Trade Organization (WTO) rules (ex: United States).

During the negotiations the sector of services was undermined, as the think tank “The UK in a changing Europe” pointed out on the paper Services and Brexit (2020). “The UK is the largest net exporter of financial and insurance services in the world and a global leader in cross-border provision of these services, exporting to more than 64 countries across all continents. The U.K.’s financial and insurance services account for close to 30 percent of the U.K.’s export of all services” (Jiří Podpiera, 2021).

Graziano et al (2018) paper showed Brexit related uncertainty decreased the number of traded products and the UK-EU bilateral flows. Additionally, the paper found sustained shocks within the economic performance of the country related to the higher likelihood of a “hard Brexit”.



Graph 23: United Kingdom Government Bond 10 year yields (in percentage)

Source: Trading Economics (<https://tradingeconomics.com/united-kingdom/government-bond-yield>)

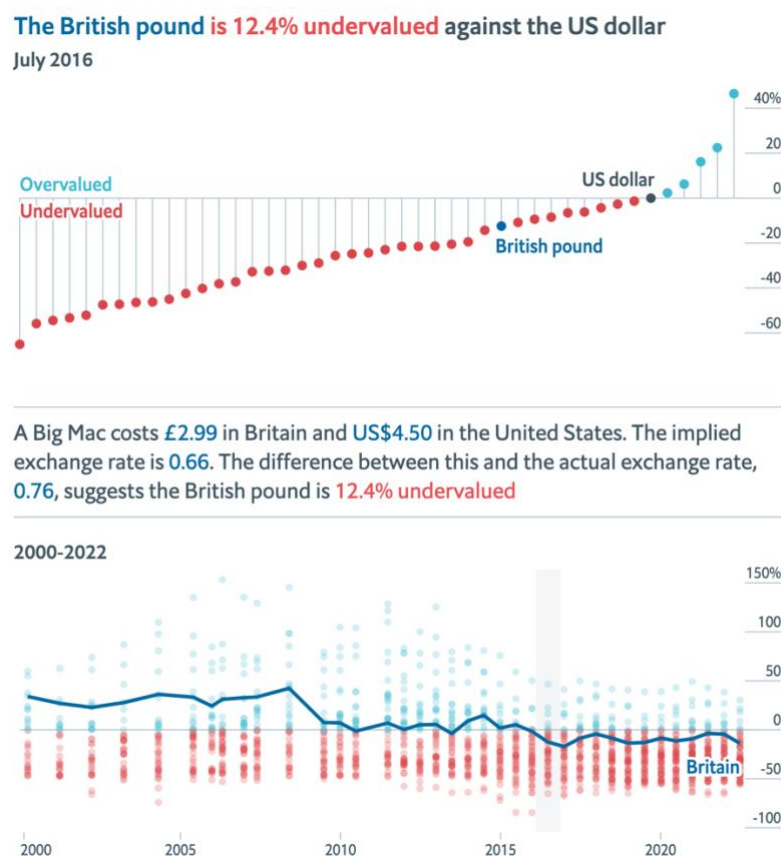
UK bonds, known as gilts, have a yield following a decreasing trend and are considered relatively safe. After the vote in June 2016, a decrease in the 10-year bond yield from 1.4 in May to 0.45 in August. The lower bond yield represents the movement of investors to safer assets, government bonds.

“The yields [which are inversely related to the price] on US and UK 10-year government bonds also dropped below the yields on shorter-term government bonds (an inversion of the normal

relationship) for a brief period in August, and the first time this has happened since the financial crisis.” – Mike Hope, 2019

Exchange rate

It must be noted that the depreciation of the sterling pound was less significant after the Brexit vote than after the 2008 crisis. The nominal exchange rate level has been extremely sensitive to political decisions surrounding Brexit theme more than economic studies, for example in October 2016 it reacted to French President François Hollande wish for a Hard Brexit and again in January 2017 with Theresa May defending a Hard Brexit position. The Business insider listed a more comprehensive list in where the Pound reacted to political news (<https://www.businessinsider.com/the-pound-in-the-year-since-the-brexit-vote-2017-6#january-16-and-17-2017-10>).



Graph 24: The Big Mac Index, British Pound against the US dollar from 2010 to 2020

Source: The Economist, July 2021 (<https://www.economist.com/big-mac-index>)

The Big Mac index can be used as a proxy for the real exchange rate. It was brought by The Economist in 1986 and is based on the purchasing-power parity theory, where the long-run exchange rate should equalize the prices of an identical bundle of goods and services in any two countries, in this case the same burger should have the same price in the US and in the UK. (The Economist, <https://www.economist.com/big-mac-index>).

Taking the example of a Big Mac in January 2016 it costed £2.89 in the UK and US\$4.29 in the US, implying an exchange rate of 0.67, which compared to the actual exchange rate at the time of 0.68 suggests a depreciation of 1.6%. One month after the 2016 vote, in July 2016 a Big Mac costed £2.89 in the UK and US\$4.50 in the US, implying an exchange rate of 0.66, comparing it to the actual exchange rate at the time of 0.76, the pound real depreciation was of 12.4%. The real depreciation of the British Pound against the American dollar has been a permanent shock since 2016. The Law of one price does not hold, the deviation inflicted by the result of the vote in 2016, created short-term frictions. The result from a real exchange rate depreciation is a reduction from the domestic demand side of purchasing power in terms of foreign goods and an increase in terms of purchasing power of domestic goods for foreign economic agents. Over the long-run the introduction of higher trade costs from leaving the EU may imply the changes of the real exchange rate to be permanent, as they constitute structural changes.

Brexit induced depreciation was an unanticipated and is a persistent shock, caused by the internal decision to change future trade policy and not by a shock to domestic or foreign economic conditions (Breinlich et al.2022).

Credit rating

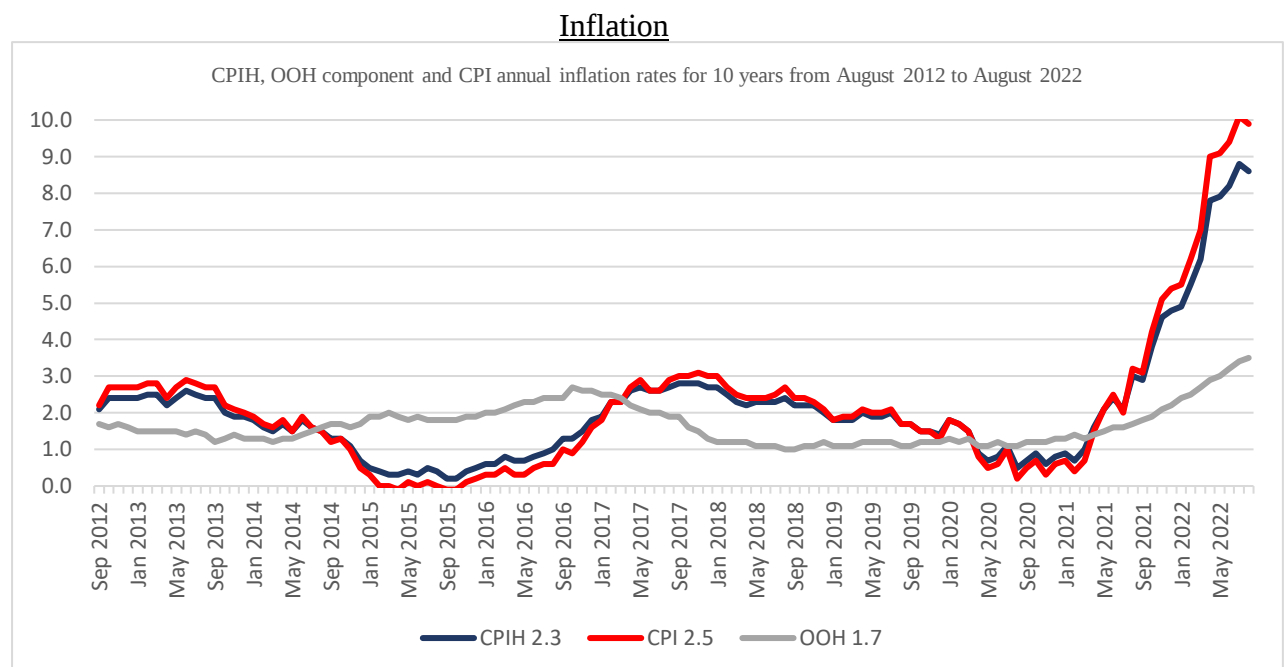
The country credit rating also was altered facing the result of the Brexit referendum. The downgrading from AA+ to AA (according to the Fitch rating; and lost its triple A rating in S&P), means the country will face a higher difficulty in borrowing from financial markets to

finance its sovereign debt. Additionally, after the official exit from the EU, the country rating downgraded further to AA-. The downgrading of the sovereign credit rating indicates an increase of risk, especially political risk.

<https://www.fitchratings.com/entity/united-kingdom-80442209>

<https://www.theguardian.com/business/2016/jun/27/property-and-financial-shares-slide-as-referendum-fallout-hits-stock-markets>

<https://www.imfconnect.org/content/dam/imf/News%20and%20Generic%20Content/GMM/Special%20Features/GMM%20Feature%20-%20Brexit%20Monitor.pdf>



Graph 25: CPIH, OOH component and CPI annual inflation rates over the last 10 years for the United Kingdom

Source: Office for National statistics – Consumer price inflation

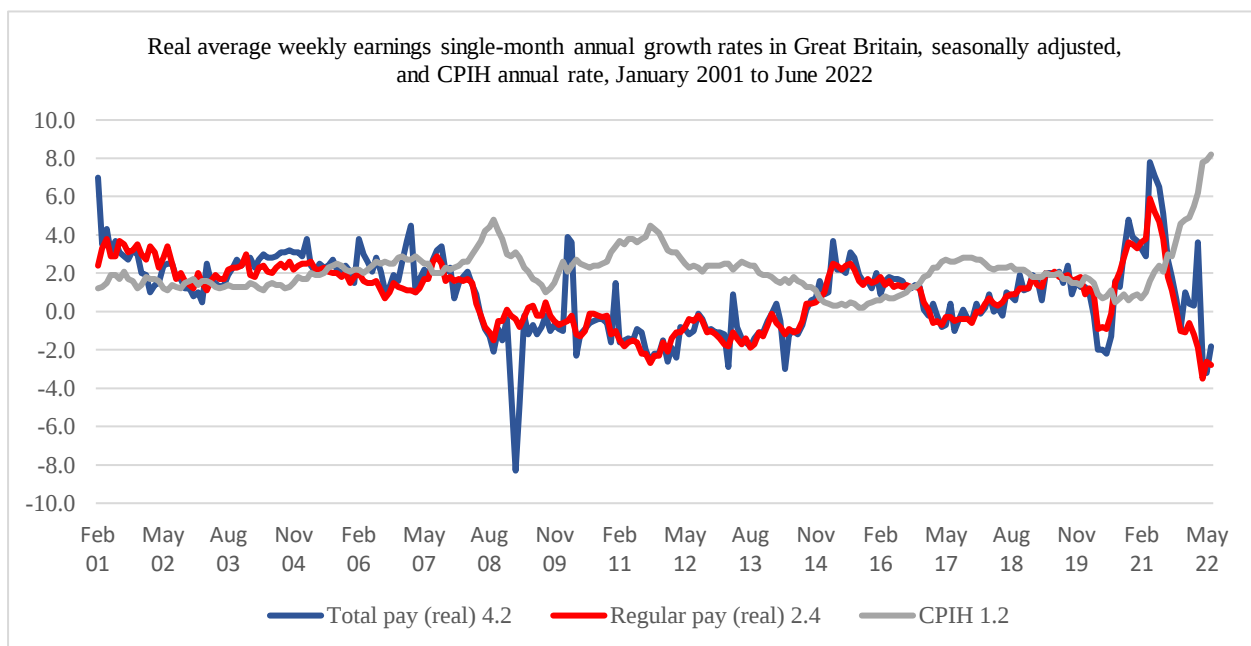
(<https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/consumerpriceinflation/august2022>)

Real wages



Graph 26: Regular real pay growth from 2001 to 2022 in the United Kingdom

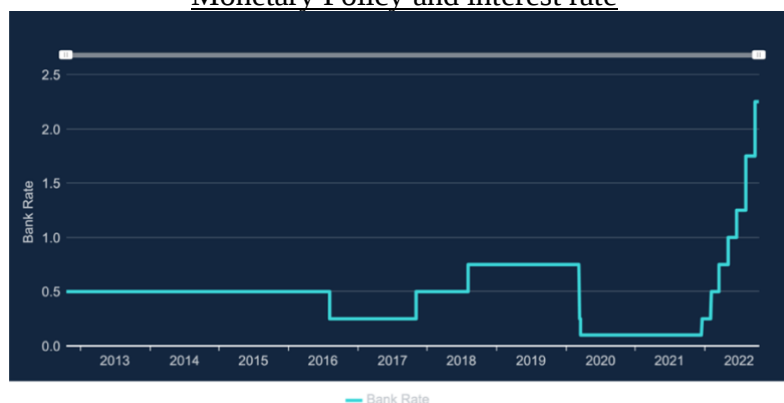
Source: The Guardian (<https://www.theguardian.com/business/2022/may/18/why-uk-highest-inflation-g7-ukraine-covid-brexid>)



Graph 27: Real average weekly earnings single-month annual growth rates in Great Britain, seasonally adjusted, and CPIH annual rate from 2001 to 2022

Source: Office for National Statistics – Monthly Wages and Salaries Survey, Office for National Statistics – Consumer price inflation (<https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/averageweeklyearningsingreatbritain/august2022>)

Monetary Policy and interest rate



Graph 28 Bank rate ²¹for the UK over the last 10 years (from 2012 to 2022)

Source: Bank of England Database (<https://www.bankofengland.co.uk/boeapps/database/Bank-Rate.asp>)

In Graph 8 we can see that since 2009, the bank rate has been stable at 0.5 percent. After the 2016 vote, the Bank of England decreased the bank rate to 0.25 for the first time since the 2008 crisis, extended the quantitative easing programme²² and launched a Term Funding Scheme²³. The cut in bank rate intended to promote confidence within the economy and help with borrowing costs, keeping consumption and lending stable. The purpose of this change was to accommodate Brexit related effects prioritizing economic growth over inflation, going against the Taylor rule²⁴. The Bank of England rationale was looking to sustain the domestic demand, despite inflation being above the target and risking further depreciation of the sterling pound (as lower interest rates are less attractive for foreign investment and decrease the currency value further). A lower bank rate with quantitative easing increases money supply and adds to the inflationary pressures. The stabilization of output was made the priority because the MPC believed the inflationary pressures from the currency depreciation would fade off and only be short-lived (Martin Weale, 2016). Afterwards in 2017 and 2018, an increase in interest rate of 0.25 percent annually was made to relieve the increase of cost of living, due to high inflation,

²¹ The Bank of England official bank rate is the rate used for monetary policy purposes.

²² Quantitative easing consists in buying government and corporate bonds from financial institutions in the expectation that banks will then lend back into the economy.

²³ The Term Funding Scheme that will provide funding for banks at rates close to the monetary policy rate.

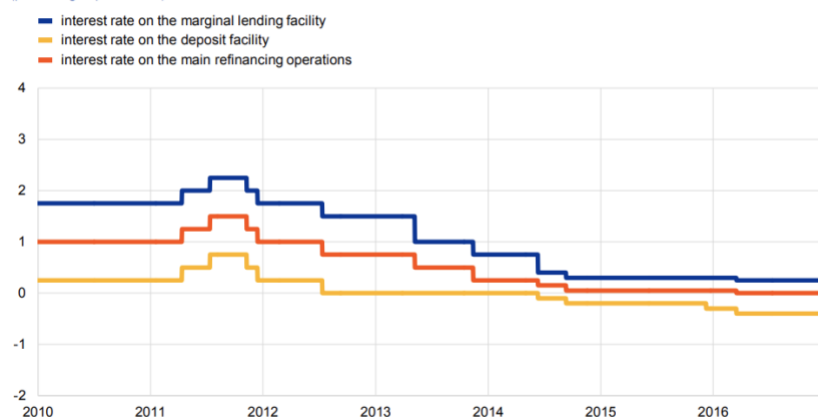
²⁴ The Taylor Rule states a higher inflation must be dealt with by applying a higher interest rate, cooling off the economy. Contrary, when inflation is low, the interest rate following the rule should be lower.

partly generated by Brexit as seen previously, and low wage growth. According to the study conducted by Martin Geiger and Jochen Güntner (2022), the adopted measures by the Bank of England to control the possible effects of Brexit shocks to the economy have been successful in protecting the economy against a stronger recession. Furthermore, the pandemic shock, in 2020, led to a decrease of the interest rate to an historical low of 0.1 percent looking to sustain borrowing and its costs. Since the end of 2021, year of the effective Brexit, interest rates have been increasing and the bank rate reached 2.25% in September 2022. This rapid increase in interest rate intends to fight high inflation, by increasing borrowing costs and as such investment and consumer spending. These last increases in interest rate can constraint further economic growth (according to the Bank of England).

Chart 23

Key ECB interest rates

(percentages per annum)



Source: ECB.

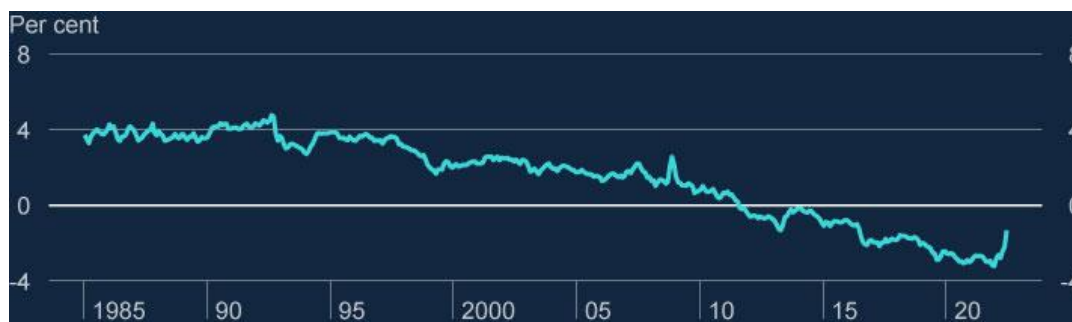
Note: The latest observation is for 7 December 2016.

Graph 29: Key ECB interest rates from 2010 to 2017

Source: Annual report of ECB, 2016

In 2016, the European Central Bank (ECB) extended its QE programme. The 2016 vote had no weight in the ECB decision to provide for monetary stimulus. The prolonged QE has the objective of reducing the inflation gap and achieve the targeted inflation of 2%, following the Taylor rule.

(Annual report of ECB, 2016, <https://www.ecb.europa.eu/pub/pdf/annrep/ar2016en.pdf>).



Graph 30: The UK ten-year real interest rate from 1985 to 2021 (ten-year zero coupon yield)

Source: Bank of England, July 2022, Speech by Andrew Bailey

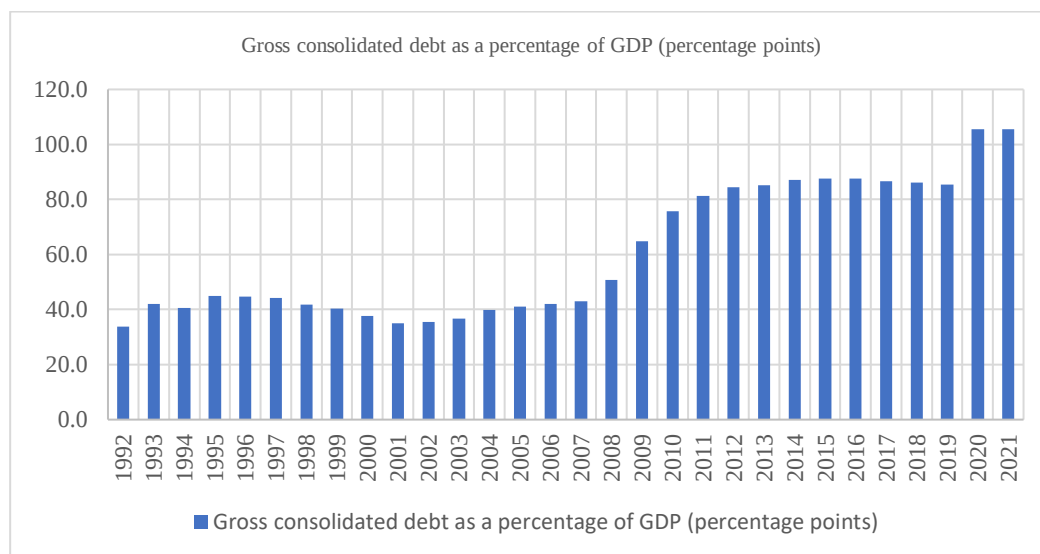
“The real interest rate can be quite responsive to cyclical shocks, sometimes moving by a percentage point or more in a matter of months. Indeed, in the past few months we have seen a relatively sharp and sizable increase. Whether such movements persist depends on the underlying shocks driving real interest rates. For example, we saw a similar rise in the ten-year real interest rate after the global financial crisis and that did not persist when inflation returned to target. (...) Lower productivity reduces the potential returns on new investment (the marginal product of capital) and this reduces firms’ demand for capital at a given interest rate. In equilibrium this reduction in demand lowers R^* ”

Fiscal Policy

The adopted austerity²⁵ policies after the 2008 crisis have been addressed by researchers as one of the causes of the “leave” result on the 2016 referendum (Fetzer, 2019), the vote was a form voicing dissatisfaction towards the government. The austerity policy continued even after the vote and is still in place nowadays. According to Simon Wren-Lewis (2019), when faced by a shock which could produce a recession authorities should prioritize output, as such when facing a recession applying austerity wastes resources, with firms retracting from investing in improved production techniques, resulting in lower productivity and lower economic growth. As the interest rate is close to the zero lower bound (right after the Brexit vote), its effectiveness

²⁵ Austerity means raise of taxes and cut in government expenses to reach balance in the public budget.

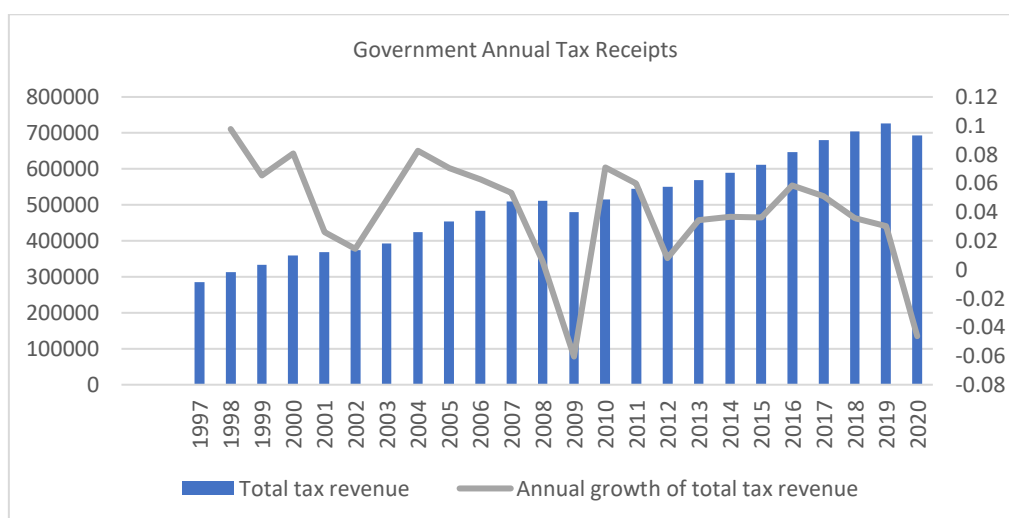
is reduced and demanded for expansionary fiscal policy. With uncertainty retracting investment (as we will see later), instead of having a fiscal stimulus to sustain economic growth, austerity retracted further the economy. As Simon Wren-Lewis (2019) notes the first quarter of 2018 was accompanied by a lower GDP per capita. The second effect of Brexit was inflation, which is better tackled through tightening fiscal policy, thus austerity. Fiscal policy will be addressed in more detail on the sub-section dedicated to government spending.



Graph 31: Gross consolidated debt as a percentage of GDP from 1992 to 2021

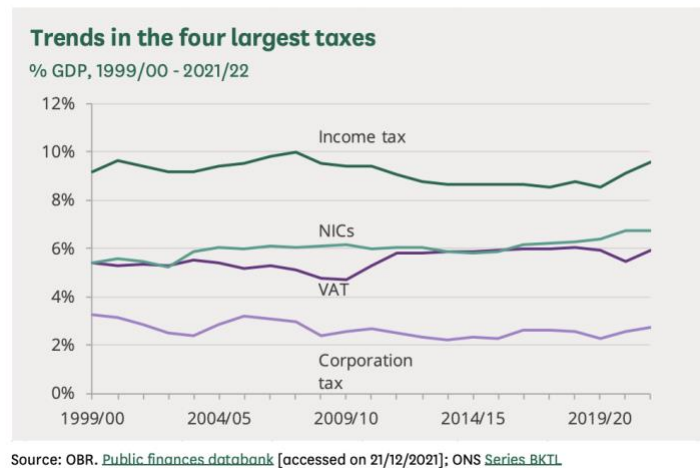
Source: UK office for national statistics

(<https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/publicsectorfinance/datasets/governmentdeficitanddebtreturn>)



Graph 32: Government annual tax revenues and tax revenues growth from 1997 to 2020

Source: own work using data from OECD Stat.

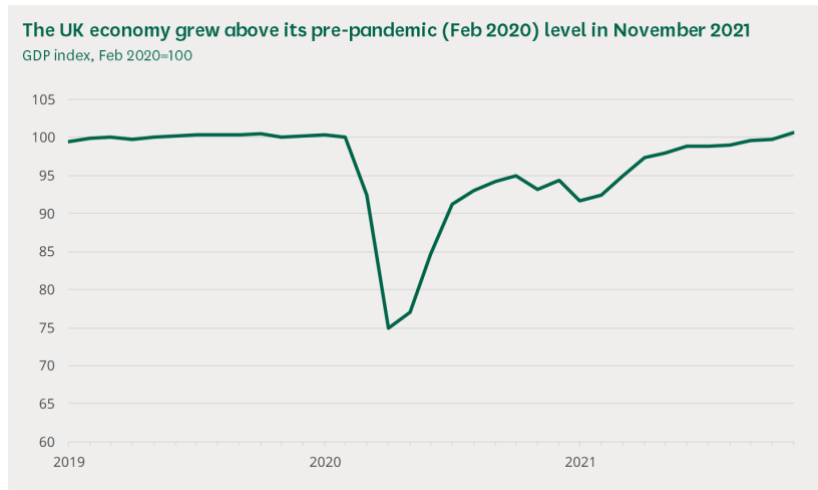


Graph 33: Largest taxes revenue as a percentage of GDP from 1999 to 2020

The government can finance these expenses through revenue made by taxation or through additional issuance of debt. Annual revenue from taxes year on year as a percentage of GDP is quite stable around 30-40%. The lowest tax revenue as a percentage of GDP correspond to periods of economic slowdown related to the 2008 crisis and the pandemic period.

According to the House of commons, the budget deficit average is 3.6% of GDP, besides periods of economic crisis. The financial crisis led to a higher budget deficit for the UK reaching 7.4% in 2008 and 10.1% in 2009. In the year of the Brexit vote, the country also incurred on a budget deficit but lower than average (deficit of 2.6%GDP). The pandemic also created a higher deficit than the average, reaching a deficit of 14.1% of GDP. Comparing to the 2008 crisis, UK in 2020 had a higher government deficit by around 7pp, this difference in impact could be potentially attributed to the different nature of the crisis or even because the Brexit shock is being felt.

Economic growth



Graph 34: UK GDP level transformed to an 2019 GDP level index, monthly estimates, from 2019 to 2022

Source: ONS. GDP monthly estimate, UK: November 2021

Deloitte (2020): The UK economic was hit the hardest from the G7 countries by the pandemic in 2020, its GDP fell by 20.4% in Q2 from Q1.

<https://www2.deloitte.com/us/en/insights/economy/impact-of-covid-19-g7-economies.html>

Britain's Recovery is Trailing Behind

UK is the only G-7 economy yet to fully recover from the pandemic

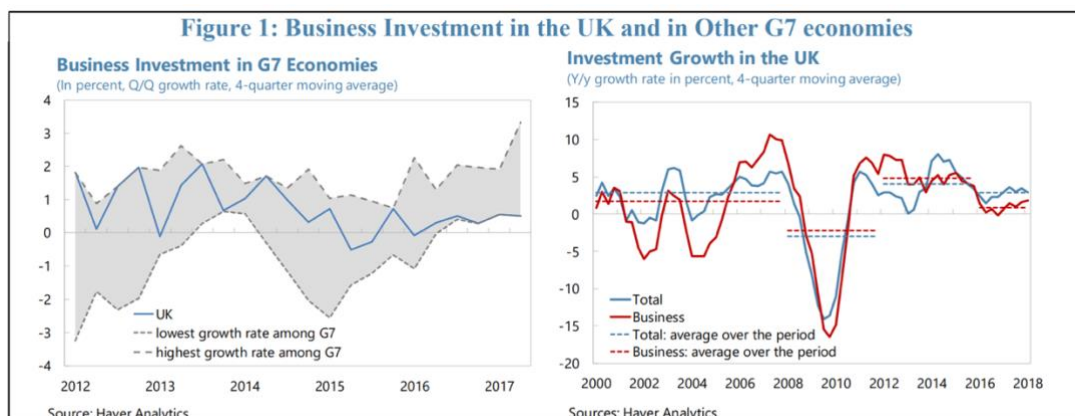


Source: ONS

Figure 1: G7 countries GDP at the end of the second quarter of 2021 compared to the end of 2019 GDP in percentage

Source: Bloomberg, 2022

Investment



Graph 35: Business Investment in UK compared to other G7 countries

Source: IMF working paper, 2018

In the pre-Brexit period, business investment in the UK outperformed investment in the other G7 countries. Whereas after the referendum period, the UK went to the bottom of the pack, becoming the country with lower growth of business investment in comparison to the other G7 economies.

INVESTMENT IN DIFFERENT PERIODS (AVERAGE CHANGE)

(% annual)

TABLE 1
Weight over Total
Investment (%)

	2000 - 2004	2005 - 2007	2008 - 2010	2011 - 2015	2016 - 2017	2005 - 2007	2016 - 2017
Gross fixed capital formation	1.3	3.3	-3.9	3.0	2.0		
Business Investment	-12	5.1	-4.0	4.0	0.7	57	57
Dwellings (private & public)	3.6	-1.1	-7.5	3.7	5.9	22	22
General Government	6.9	11.3	7.8	-13	0.4	12	16
<i>Breakdown by asset type</i>							
Transport equipment	2.9	-0.3	-13	11.2	4.3	5	7
ICT equipment and other machinery	15	4.8	-4.9	3.6	-14	20	19
Dwellings	3.6	-1.1	-7.5	3.7	5.9	22	22
Other buildings and structures	-0.2	5.0	-3.8	2.5	16	35	33
Intellectual property products	0.9	4.5	0.2	10	0.9	19	18
<i>PRO-MEMORIA</i>							
Gross Domestic Product	2.9	2.8	-10	2.1	17		
Capacity utilisation (Manufacturing) (2)	64.0	56.7	64.3	51.6	49.0		
FDI net inflows into UK (% GDP) (3)	-19	13	-13	19	2.9		

(1) Average weights in current prices. The sectoral weights do not add 100 since dwellings do not include costs of ownership transfer. They are included in Other buildings and structures

(2) Average % companies below capacity

(3) Annual (4Q) moving average. In 2017 FDI net inflows turned negative (outflows) amounting -3 % GDP

SOURCE: ONS

Graph 36: Gross fixed capital formation change by components, from 2000 to 2017

Source: Bank of Spain, 2018

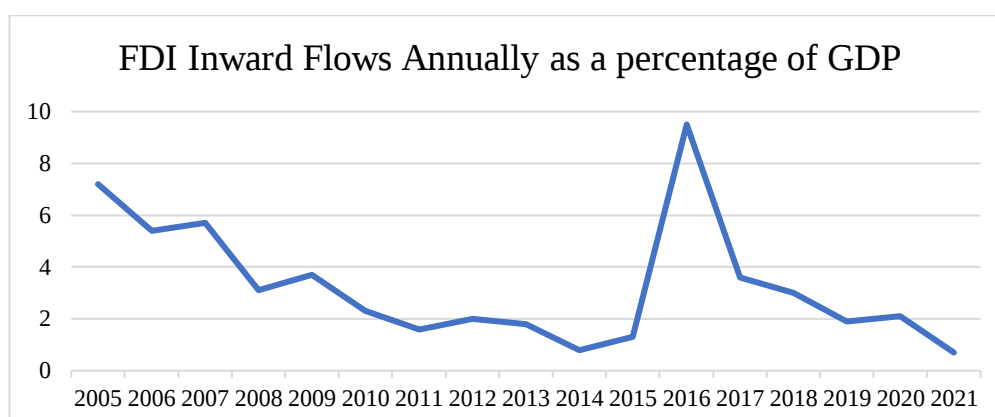
Gross Fixed Capital Formation = Gross Business Fixed Investment + Gross Residential Construction Investment + Gross Public Investment

Residential investment grew in the post-referendum period at a higher rate than in pre-Brexit period. The increasing in housing was supported by the demand from first-time buyers, whom used the Help to buy equity loan scheme implemented by the Cameron's government (Bank of England Survey 2018).

Foreign Direct Investment

FDI is a form of investment and has been proven as having a positive effect on economic growth both directly and indirectly (Argiro Moudatsou, 2003; Pain and Young, 2004; Haskel

et al 2002; Dhiangra et al. 2016; de Almeida et al. 2019). The Brexit vote impacted both inward and outward investment in the UK, as detailed below.



Graph 37: FDI Inward Flows Annually as a percentage of GDP

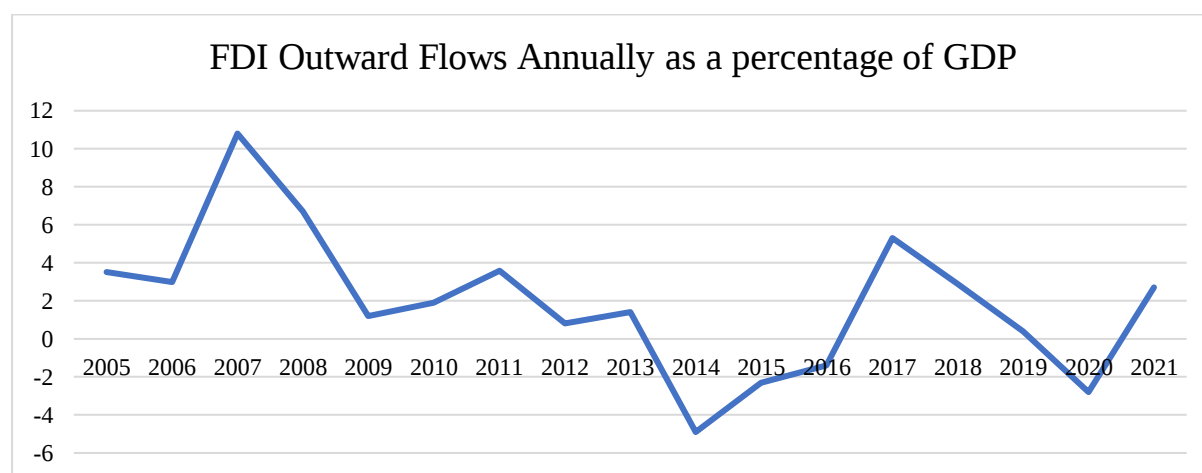
Source: own work using data from OECD statistics

Inward investment:

Graph 18 shows, in 2016, inward FDI flows were unusually high (9.6% of GDP) due to a higher number of mergers and acquisitions of UK firms by foreign companies. The House of Commons (2020) argued a possible reason for this unusual M&A number is the depreciation of the pound, result from uncertainty and negative expectations. Foreign firms with the fall in value of the pound were able to acquire UK firms at a cheaper price. Additionally, some foreign firms were seeking to avoid new trade costs and continue to serve the UK market by investing in new units in the UK (Patrick Bisciari, 2019). Since 2016, inward FDI flows decreased substantially (for example, 3.6% of GDP in 2017 and 3% in 2018). Inward FDI post-referendum continued to grow, but at a lower rate.

Brexit was perceived as a reduction in attractiveness of the country, as the UK became less open, it also became a less desirable destination for investment with the future increase costs to trade with the EU (Teresa Sastre, 2018). Following the implementation of the TCA agreement on 2021, EU agents investing in the UK have significant lower guarantees of legal protection against discriminatory practices by the UK government in what concerns their

investment (Debevoise and Plimpton, 2021), which reduces the UK attractiveness for FDI. Although the pound depreciation potentially contributed to an increase in investment by foreigners to the UK, as suggested by Lucyna Górnicka, the overall impact on inward FDI was negative. Bank of Spain found a post-referendum fall in announced projects and capital expenditures into the UK by other EU countries as well as one of the most important non-EU partners, the United States. According to Breinlich et al.(2019), a 11 percent reduction of new investment by EU country members was felt right after the Brexit vote. Serwicka and Tambari (2018) findings also support this result, their analysis showed that the Brexit vote may reduce the number of FDI projects to the UK by 16-20 percent. They identified a larger gap for services FDI, which could be due to negotiations developments, as services were somewhat “left behind” during the transition period. It could be expected this gap to increase as the TCA agreement does not comprehend services access to the EU market.



Graph 38: FDI Outward Flows as a percentage of GDP from 2005 to 2021

Source: own work using data from OECD statistics

Outward investment:

Before the referendum UK was lowering FDI flows to other countries and even disinvesting in foreign economies (Graph 19). However, right after 2016 there was a rapid increase in outward FDI flows (reached 5.3% GDP in 2017), showing a clear change of trends. Research conducted by Breinlich et al (2019) presented the vote results as cause to an increase of 17% in

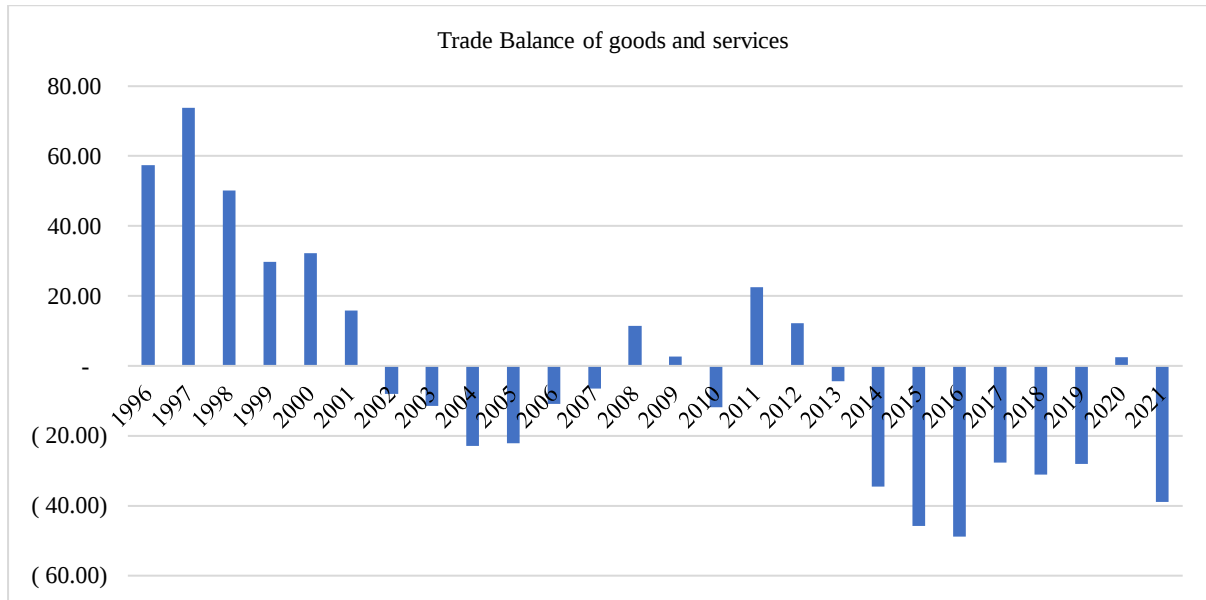
investments by UK firms in the EU. The study explains these new investments were created to have access to EU markets, as UK investments outside the EU have not felt an impact. The paper estimated an increase of £8.3 billion in UK investment in the UE between the Brexit result and the end of 2018. It is important to note the increase in outward FDI has been directed to the services sector, suggesting a diversion from internal investment to outward investment. As previously mentioned, the services sector was not made a priority during the negotiations, which could have had a negative impact on investors' expectations and led them to take precautionary measures to face the rising political and economic uncertainty.

The lower FDI inflows and higher FDI outflows diminish the available resources within the economy for investment, thus can contract economic growth. The sterling pound depreciation helped generating some FDI inflows. However, the overall change of regulatory context combined with the future limited access to the EU decreases the attractiveness of the UK as a destination of FDI and leads domestic firms to invest abroad.

Summary for FDI : Foreign direct investment (FDI) is a form of investment important for economic growth and was affected by the Brexit vote and TCA implementation. Post-referendum inward and outward FDI increased, with foreign firms looking for a way to continue to serve the UK market and domestic firms looking to still access the EU market. The depreciation of the pound helped sustain inwards FDI post-referendum. After the TCA implementation, UK became less attractive for FDI with the new trade costs and regulation implemented, thus inward FDI decreased and outwards FDI increased. The service sector was more impacted by these flows, as it was noted a diversion from internal to outward investment. The lower FDI inflows and higher FDI outflows diminish the available resources within the economy for investment, thus can contract economic growth. The sterling pound depreciation helped generating some FDI inflows. However, the overall change of regulatory context

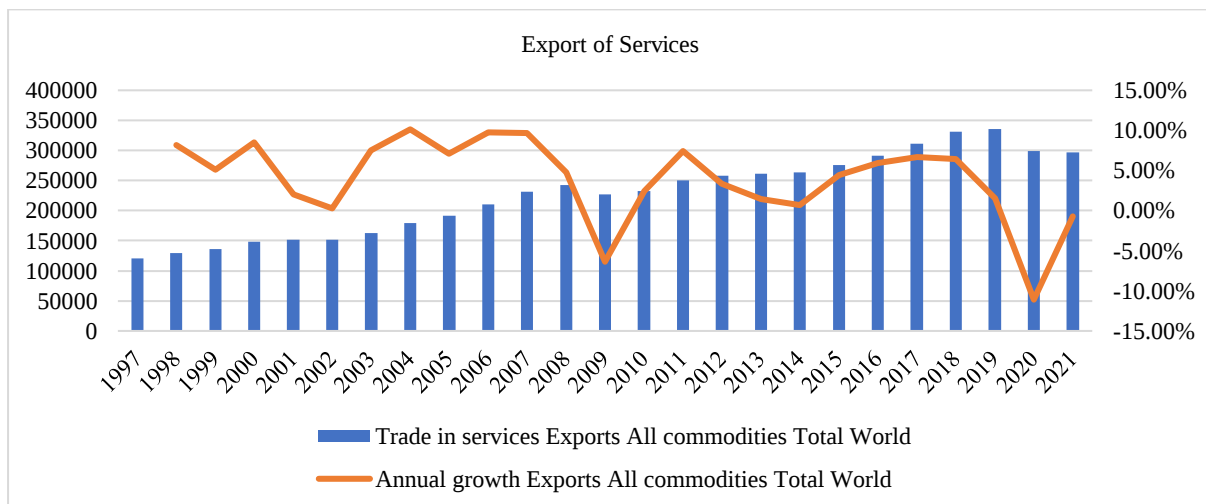
combined with the future limited access to the EU decreases the attractiveness of the UK as a destination of FDI and leads domestic firms to invest abroad.

Trade



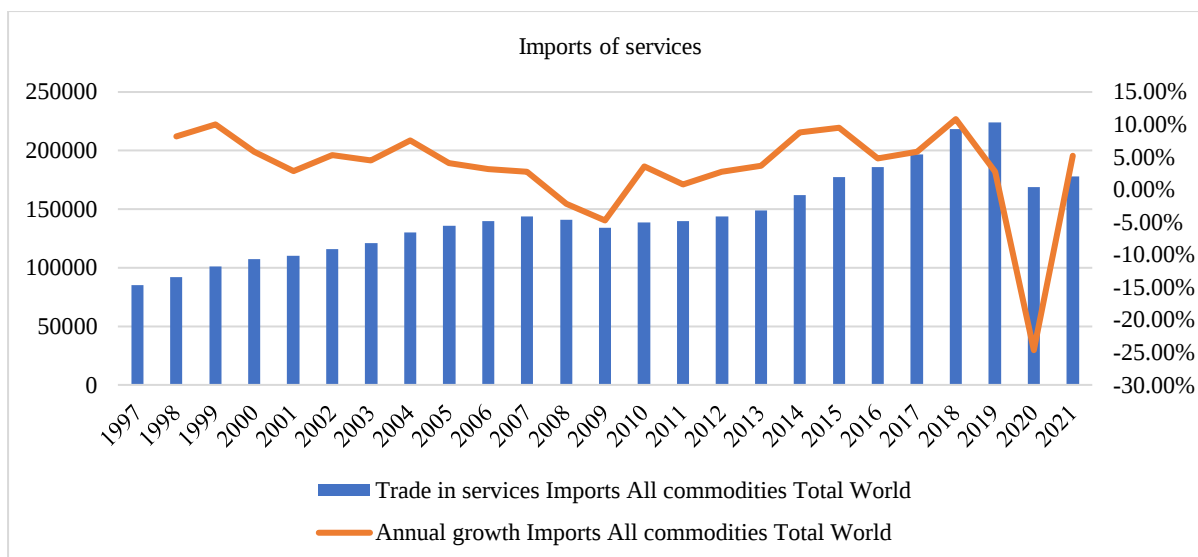
Graph 39: Trade Balance of G&S, constant US\$ 2015

Source: own work using data from ONS



Graph 40: Total service exports and annual export change, from 1997 to 2021

Source: Office of National Statistics, Balance of payments 2022



Graph 41: Service imports and annual service imports change from 1997 to 2021

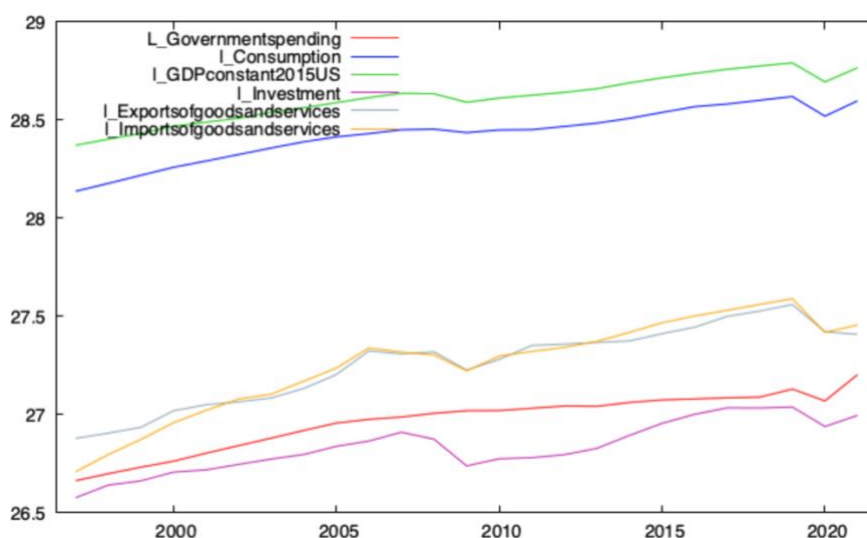
Source: own work using ONS stats.

Annex II: Model

Nature of the series

Trend and business cycles analysis

Graph 35 shows the evolution of the studied variables. UK GDP follows a positive trend in the period of 1997 - 2021. Consumption and GDP follow similar paths, indicating the important role displayed by consumption growth for economic growth. Exports and Imports follow very close paths to one another. Throughout the 25-year period, two recessions can be noted: the 2008 crisis and the pandemic. Investment seems to react more promptly to these recessions, altering the variable trend.



Graph 42: GDP, Consumption, Government spending, Investment, Exports and Imports in logarithm terms from 1997 to 2021, for the UK

Stationarity

To study the time-series model, we first must assess the presence of unit root within the variables. For that we used the ADF test, with a constant and with constant and trend. The ADF test null hypothesis corresponds to a variable having a unit root, thus rejecting the null translates to a stationary process.

Table 2: Testing for stationarity results

	P-value of ADF		P-value of ADF	
	In level		In first difference	
	Constant	Constant and Trend	Constant	Constant and Trend
L (GDP)	0.396	0.2695	0.00021	0.00058
L(C)	0.1941	0.317	0.00028	0.00023
L(Gov)	0.5166	0.4131	3.245e-05	3.033e-08
L(Inv)	0.4161	0.5038	0.00426	0.02352
L(X)	0.2861	0.869	0.00506	0.00875
L(M)	0.04995	0.6979	0.00391	0.00343

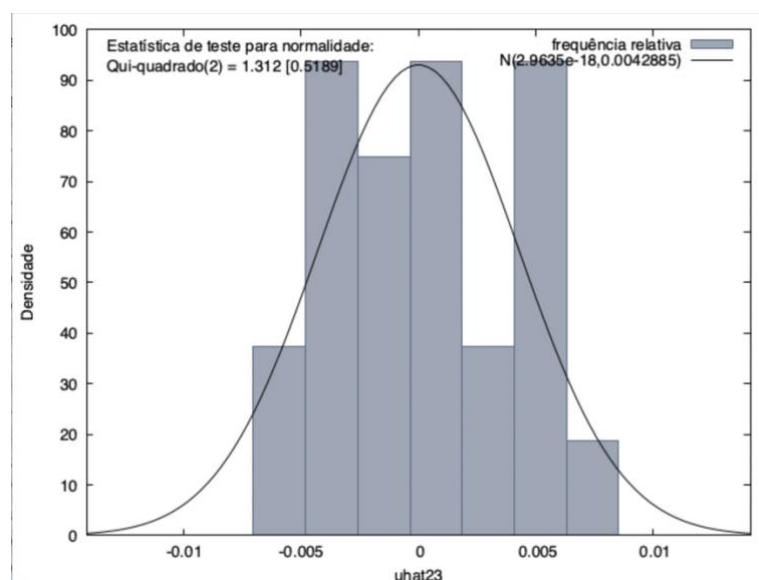
Looking at the results from Table 1, we do not reject the condition of non-stationarity, because to reject the null the p-value should be under 0.05²⁶. Thus, the variables in logarithms are non-stationary and using them could risk producing non-sense conclusions (spurious results). To assess the order of integration within the series we must use the first difference of the variables, which are stationary²⁷. We can say the series being studied is a Difference Stationary Process, which means the series has a stochastic trend. By removing the trend, stationary stochastic process arises and shocks affecting the system might produce a permanent effect.

Model Specification

To estimate our model using OLS, the model must follow the Gauss Markov assumptions to insure it gives you the best linear unbiased estimates.

Normal distribution of the residuals

To elaborate valid inferences from your regression, the residuals of the regression should follow a normal distribution.



Graph 43:Residuals, testing normality

²⁶ Throughout the report we will use the 5% significance level.

²⁷ We computed again the ADF test to check if in fact the first differences of the logarithms of the variables were stationary.

Regarding Graph 36, we can say residuals do not follow a bell-shaped symmetrical curve centred around the mean. If normality is violated, normally it testifies to having outliers within the data, which is likely because of the 2008 crisis and the pandemic.

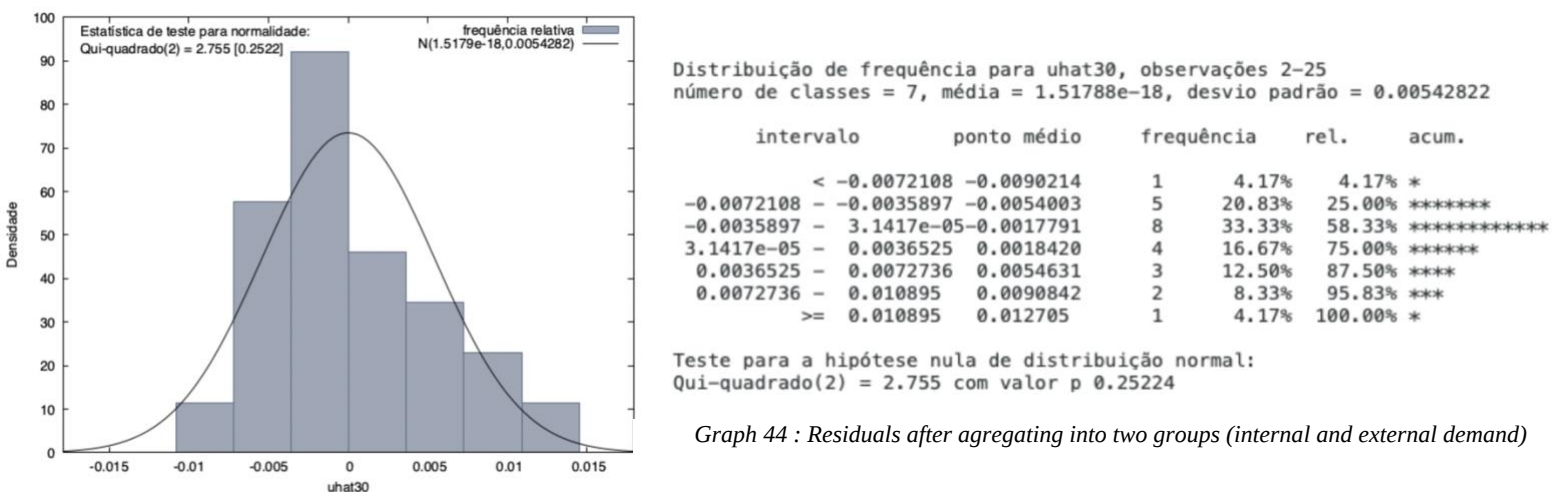
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Teste da normalidade dos resíduos -
Hipótese nula: o erro tem distribuição Normal
Estatística de teste: Qui-quadrado(2) = 1.31204
com valor p = 0.518912

```

Figure 2: Result for testing the normality of the model residuals

We will use the Model with aggregates (internal and external demand) because it makes the model non-colinear, but it also makes the error term following an almost normal distribution.



Graph 44 : Residuals after aggregating into two groups (internal and external demand)

Non-Collinearity: the regressors estimated aren't perfectly correlated with each other

Multicollinearity occurs when independent variables in a regression model are correlated. If the correlation is high, the standard deviation of the coefficient can become very large, and so it can have an impact on estimates (no longer precise). Looking at **Figure 1**, there is an indication of possible problem of multicollinearity between variables. The Variance Inflation Factor technique can be used to detect the amount of collinearity in a multiple regression model, the results are shown below.

```

Coeficientes de Correlação, usando as observações 1998 - 2021
5% valor crítico (bilateral) = 0.4044 para n = 24

d_l_Government~ d_l_Consumption d_l_Investment d_l_Exportsofg~
1.0000 0.8165 0.4278 0.2804 d_l_Government~
0.0000 1.0000 0.7570 0.5971 d_l_Consumption
0.0000 0.0000 1.0000 0.6704 d_l_Investment
0.0000 0.0000 0.0000 1.0000 d_l_Exportsofg~

d_l_Importsofg~
0.5027 d_l_Government~
0.8191 d_l_Consumption
0.7871 d_l_Investment
0.8812 d_l_Exportsofg~
1.0000 d_l_Importsofg~

```

Figure 3: Correlation matrix between independent variables

```

Factores de Inflaccionamento da Variância (VIF)
Valor mínimo possível = 1,0
Valores > 10,0 podem indicar um problema de colinearidade

d_l_Governmentspending 4.618
d_l_Consumption 12.428
d_l_Investment 3.381
d_l_Exportsofgoodsandservices 5.711
d_l_Importsofgoodsandservices 12.004

VIF(j) = 1/(1 - R(j)^2), onde R(j) é o coeficiente de correlação múltipla
entre a variável j e a outra variável independente

Diagnósticos de colinearidade de Belsley-Kuh-Welsch:

proporções de variância

lambda cond const d_l_Gove~ d_l_Cons~ d_l_Inve~ d_l_Expo~ d_l_Impo~
4.247 1.000 0.014 0.005 0.003 0.010 0.006 0.003
0.870 2.209 0.312 0.035 0.001 0.035 0.030 0.005
0.512 2.880 0.513 0.073 0.014 0.008 0.050 0.001
0.268 3.977 0.141 0.043 0.000 0.595 0.110 0.011
0.071 7.759 0.009 0.405 0.151 0.263 0.453 0.298
0.032 11.449 0.011 0.439 0.831 0.088 0.352 0.681

lambda = eigenvalues of inverse covariance matrix (smallest is 0.0323943)
cond = índice da condição
nota: a soma da coluna das proporções de variância é 1.0

According to BKW, cond >= 30 indicates "strong" near linear dependence,
and cond between 10 and 30 "moderately strong". Parameter estimates whose
variance is mostly associated with problematic cond values may themselves
be considered problematic.

Count of condition indices >= 30: 0

Count of condition indices >= 10: 1
Variance proportions >= 0.5 associated with cond >= 10:

d_l_Cons~ d_l_Impo~
0.831 0.681

```

Figure 4: VIF of model of first differences of the variables in logarithms

A VIF value of 1 indicates no correlation between that explanatory variable and any other explanatory variables of the model. If it is between 1 and 5 it indicates moderate correlation, not severe enough to require attention. Values greater than 5 represent severe correlation between that explanatory variable and other explanatory variables in the model, in that case, the coefficient estimates and p-values in the regression output are likely unreliable. Looking at

the results Figure 2, there is a high degree of multicollinearity in our data. In figure 1, we can see government and consumption are highly correlated with each other. As for exports and imports among each other, and with investment.

One way to solve multicollinearity is to aggregate the variables, thus we will aggregate in two groups: internal and external demand, which have low levels of collinearity between them.

Table 3: Adaptation of model to be non-collinear

Factores de Inflaccionamento da Variância (VIF)				
Valor mínimo possível = 1,0				
Valores > 10,0 podem indicar um problema de colinearidade				
d_l_Internaldemand	1.504			
d_EXTERNAL_DEMAND	1.504			
VIF(j) = 1/(1 - R(j)^2), onde R(j) é o coeficiente de correlação múltipla entre a variável j e a outra variável independente				
Diagnósticos de colinearidade de Belsley-Kuh-Welsch:				
proporções de variância				
lambda	cond	const	d_l_Inte~	d_EXTERN~
2.004	1.000	0.096	0.096	0.096
0.688	1.706	0.627	0.005	0.334
0.308	2.551	0.277	0.899	0.570
lambda = eigenvalues of inverse covariance matrix (smallest is 0.307901)				
cond = índice da condição				
nota: a soma da coluna das proporções de variância é 1.0				
According to BKW, cond >= 30 indicates "strong" near linear dependence, and cond between 10 and 30 "moderately strong". Parameter estimates whose variance is mostly associated with problematic cond values may themselves be considered problematic.				
Count of condition indices >= 30: 0				
Count of condition indices >= 10: 0				
No evidence of excessive collinearity				

Homoscedasticity: the error of the variance is constant

Breusch-Pagan and White Test are used to test for heteroskedasticity in a linear regression model. The null for both tests consists in a homoscedastic situation, where residuals are distributed with an equal variance.

Table 4 : Results of White test for heteroskedasticity

Teste de White para a heterocedasticidade
Mínimos Quadrados (OLS), usando as observações 1998-2021 (T = 24)
Variável dependente: uhat^2

	coeficiente	erro padrão	rácio-t	valor p
const	1.67668e-05	1.06985e-05	1.567	0.2151
d_L_Governmentsp~	-0.000862343	0.000998387	-0.8637	0.4513
d_L_Consumption	-0.00195612	0.00103051	-1.898	0.1539
d_L_Investment	-0.00144489	0.000765996	-1.886	0.1557
d_L_Exportsofgoo~	-0.000657217	0.000611630	-1.075	0.3613
d_L_Importsofgoo~	0.00284256	0.00115705	2.457	0.0911 *
sq_d_L_Governmen~	-0.00193497	0.0205536	-0.09414	0.9309
X2_X3	0.0197542	0.0684596	0.2886	0.7917
X2_X4	-0.00253268	0.0191040	-0.1326	0.9029
X2_X5	0.0215019	0.0204201	1.053	0.3697
X2_X6	-0.0130026	0.0274015	-0.4745	0.6675
sq_d_L_Consumpti~	0.00528909	0.0777561	0.06802	0.9500
X3_X4	0.0995267	0.0597458	1.666	0.1943
X3_X5	0.0429259	0.0423498	1.014	0.3854
X3_X6	-0.0776121	0.0640311	-1.212	0.3122
sq_d_L_Investment	0.00421741	0.00642604	0.6563	0.5585
X4_X5	0.00818918	0.00825593	0.9919	0.3944
X4_X6	-0.0338950	0.0226943	-1.494	0.2321
sq_d_L_Exportsof~	0.00492402	0.0132773	0.3709	0.7354
X5_X6	-0.0319969	0.0303668	-1.054	0.3694
sq_d_L_Importsof~	0.0214464	0.0179287	1.196	0.3175

R-quadrado não-ajustado = 0.928561

Estatística de teste: $TR^2 = 22.285455$,
com valor p = $P(\text{Qui-quadrado}(20) > 22.285455) = 0.325224$

Table 5 : Results for Breusch-Pagan test for heteroskedasticity

Teste de Breusch-Pagan para a heterocedasticidade
Mínimos Quadrados (OLS), usando as observações 1998-2021 (T = 24)
Variável dependente: uhat^2 escalada

	coeficiente	erro padrão	rácio-t	valor p
const	1.01747	0.242771	4.191	0.0005 ***
d_L_Governmentsp~	-10.8396	13.1129	-0.8266	0.4193
d_L_Consumption	-4.95894	22.4849	-0.2205	0.8279
d_L_Investment	9.11131	7.56154	1.205	0.2438
d_L_Exportsofgoo~	-7.85201	8.91590	-0.8807	0.3901
d_L_Importsofgoo~	10.7799	11.6881	0.9223	0.3686

Soma de quadrados explicada = 6.17259

Estatística de teste: LM = 3.086294,
com valor p = $P(\text{Qui-quadrado}(5) > 3.086294) = 0.686684$

In both tests (Table 2 and Table 3), we cannot reject the null hypothesis at any conventional significance level (10%; 5%; 1%). Hence, we can assume that homoskedasticity is present.

```

Teste de White para a heterocedasticidade -
Hipótese nula: sem heterocedasticidade
Estatística de teste: LM = 4.84946
com valor p = P(Qui-quadrado(5) > 4.84946) = 0.434527

Teste de Breusch-Pagan para a heterocedasticidade -
Hipótese nula: sem heterocedasticidade
Estatística de teste: LM = 1.99176
com valor p = P(Qui-quadrado(2) > 1.99176) = 0.369398

```

Figure 5 : Results for White and Breusch-Pagan test after aggregating the variables into groups (internal and external demand)

Exogeneity: the regressors estimated aren't correlated with the error term

When endogeneity is present in the estimated model, we cannot use the OLS estimators for the coefficients because it leads to biased and inconsistent results. There are four potential sources of endogeneity: omitted variable bias, measurement error, simultaneity, and autocorrelation. The measurement error can be ignored in our case, and autocorrelation is for dynamic models, which ours isn't.

Autocorrelation

Durbin-Watson test is commonly used to test autocorrelation, over one period. An outcome close to 2 means a very low level of autocorrelation, which is the case for the first difference of our variables in logarithms. Thus, we can conclude there is no trend nor pattern between observations in two different points in time.

```

Estatística de Durbin-Watson = 1.33276
valor p = 0.0249969

```

Figure 6: Results test autocorrelation for model with the first difference of the log variables

Source: Own work using data from World Development indicators

Our sample is not large ($T=24$, less than 30 observations); so, the use of Durbin-Watson is more appropriate than the Breusch-Godfrey test.

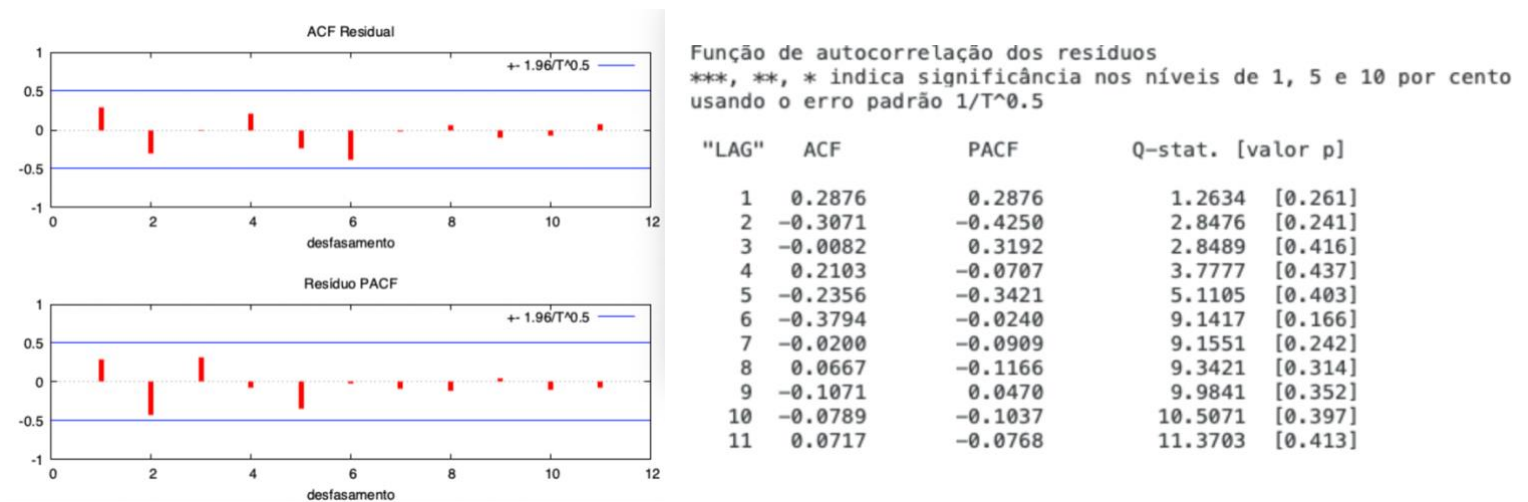
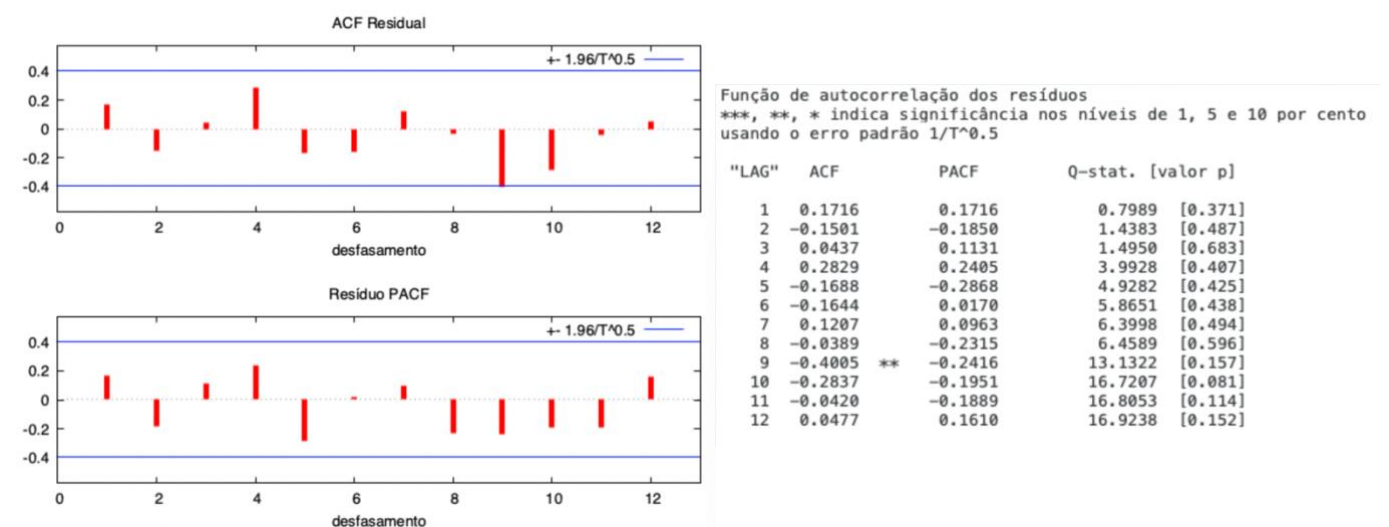


Figure 7: ACF and PCF for the error terms of version 1 of the model

There is no significant autocorrelation among the residuals in the initial model. However, by aggregating the variables into internal and external demand autocorrelation between the residuals increases. By introducing a dummy indicating the years where there was a crisis, we were able to eliminate this autocorrelation between the error terms.



Version 1 of the model :

$$d_{L(Y_t)} = a_0 + b_0 d_{L(C_t)} + b_1 d_{L(G_t)} + b_2 d_{L(I_t)} + b_3 d_{L(X_t)} - b_4 d_{L(M_t)} + \varepsilon_t$$

Where $d_{L(Y_t)}$ represents the first difference of the log of GDP; $d_{L(C_t)}$ denotes the first difference of log of private consumption of G&S; $d_{L(G_t)}$ the first difference of the log of government spending on G&S; $d_{L(I_t)}$ the first difference of log of investment on capital goods; $d_{L(X_t)}$ the first difference of log of gross exports and $d_{L(M_t)}$ the first difference of log of gross imports.

This version is stationary, homoscedastic and has no significant autocorrelation between the error terms. However, multicollinearity is present and error terms are not normally distributed.

Modelo 33: Mínimos Quadrados (OLS), usando as observações 1998-2021 (T = 24)				
Variável dependente: d_l_GDPconstant2015US				
	coeficiente	erro padrão	rácio-t	valor p
const	-0.00165395	0.00110109	-1.502	0.1504
d_l_Governmentsp~	0.0965486	0.0594737	1.623	0.1219
d_l_Consumption	0.665456	0.101980	6.525	3.91e-06 ***
d_l_Investment	0.197517	0.0342955	5.759	1.85e-05 ***
d_l_Exportsofgoo~	0.162308	0.0404381	4.014	0.0008 ***
d_l_Importsofgoo~	-0.124843	0.0530115	-2.355	0.0301 **
Média var. dependente	0.016424	D.P. var. dependente	0.030586	
Soma resíd. quadrados	0.000331	E.P. da regressão	0.004289	
R-quadrado	0.984614	R-quadrado ajustado	0.980341	
F(5, 18)	230.3849	valor P(F)	1.17e-15	
Log. da verosimilhança	100.2411	Critério de Akaike	-188.4821	
Critério de Schwarz	-181.4138	Critério Hannan-Quinn	-186.6069	
rho	0.304591	Durbin-Watson	1.332760	

Excluindo a constante, o valor p foi o maior para a variável 23 (d_l_Governmentspending)

Version 2 of the model:

$$d_{L(Y_t)} = a_0 + b_0 d_{L(Int)} + b_1 d_{L(Ext)} + \varepsilon_t$$

Where $d_{L(Int)}$ represents the first difference of the log of Internal demand and $d_{L(Ext)}$ denotes the first difference of the log of external demand (which corresponds to net exports).

This version is stationary, homoscedastic, non-collinear and has a distribution similar to normal.

There is problem that surges from aggregation, that is autocorrelation between the error terms.

Modelo 31: Mínimos Quadrados (OLS), usando as observações 1998–2021 (T = 24)
Variável dependente: d_l_GDPconstant2015US

	coeficiente	erro padrão	rácio-t	valor p	
const	-0.00240529	0.00131542	-1.829	0.0817	*
d_l_Internaldema~	1.05349	0.0445343	23.66	1.28e-16	***
d_EXTERNAL_DEMAND	0.430165	0.115566	3.722	0.0013	***
Média var. dependente	0.016424	D.P. var. dependente		0.030586	
Soma resíd. quadrados	0.000619	E.P. da regressão		0.005428	
R-quadrado	0.971242	R-quadrado ajustado		0.968503	
F(2, 21)	354.6175	valor P(F)		6.56e-17	
Log. da verosimilhança	92.73532	Critério de Akaike		-179.4706	
Critério de Schwarz	-175.9365	Critério Hannan-Quinn		-178.5330	
rho	0.179597	Durbin-Watson		1.611878	

Teste LM para autocorrelação até à ordem 5 -
Hipótese nula: sem autocorrelação
Estatística de teste: LMF = 0.918688
com valor p = P(F(5, 16) > 0.918688) = 0.493901

Version 3 of the model:

$$d_{L(Y_t)} = a_0 + b_0 d_{L(Int)} + b_1 d_{L(Ext)} + \delta_t + \varepsilon_t$$

δ_t is a time dummy, identifying the years which had a crisis.

This version is stationary, homoscedastic, non-colinear and has a distribution similar to normal.

Additionally, the time dummy solved the autocorrelation problem.

Modelo 32: Mínimos Quadrados (OLS), usando as observações 1998–2021 (T = 24)
Variável dependente: d_l_GDPconstant2015US

	coeficiente	erro padrão	rácio-t	valor p	
const	-0.00108316	0.00166202	-0.6517	0.5220	
d_l_Internaldema~	1.01613	0.0528228	19.24	2.27e-14	***
d_EXTERNAL_DEMAND	0.440011	0.114169	3.854	0.0010	***
Crise	-0.00666590	0.00524276	-1.271	0.2182	
Média var. dependente	0.016424	D.P. var. dependente		0.030586	
Soma resíd. quadrados	0.000573	E.P. da regressão		0.005350	
R-quadrado	0.973393	R-quadrado ajustado		0.969402	
F(3, 20)	243.8918	valor P(F)		6.50e-16	
Log. da verosimilhança	93.66806	Critério de Akaike		-179.3361	
Critério de Schwarz	-174.6239	Critério Hannan-Quinn		-178.0860	
rho	-0.029359	Durbin-Watson		2.039761	

Excluindo a constante, o valor p foi o maior para a variável 33 (Crise)

To determine the effect of each component to economic growth, a model using instrumental variables was created. The multicollinearity problem comes from the following variables: Consumption; Imports. These variables can also be related to problems of endogeneity, thus the high correlation with the other independent variables. Through the correlations, we can see it is consumption and imports are the source of endogeneity.

```
. corr DLGov DLCons DLinvs DLexp DLimp
(obs=24)
```

	DLGov	DLCons	DLinv	DLexp	DLimp
DLGov	1.0000				
DLCons	0.8165	1.0000			
DLinv	0.4278	0.7570	1.0000		
DLexp	0.2804	0.5971	0.6703	1.0000	
DLimp	0.5027	0.8190	0.7871	0.8812	1.0000

A way to obtain BLUE estimates is to use the IV estimation method. To choose the appropriate iv for each endogenous variable, we looked at what determined them.

What determines consumption? The main determinant of consumption demand is disposable income. Disposable income is all the income households have at their disposal to spend. It is defined as national income (GNP) minus taxes taken away by the government, plus transfer payments that the government pays out to people. A useful IV for consumption would be tax revenues from income taxation. The income tax is set by the government. If you are not interested in explaining government behaviour, tax income revenues variable is exogenous.

What determines imports? Imports are also determined by disposable income but have been associated with labour productivity. Thus, we will use labour productivity as an IV.

Earnings will also be used as IV, for both the variables, in case one of our IV are not endogenous or don't satisfy conditions for a good instrument.

Data was retrieved from the Office for National Statistics. A data limitation surged for the income taxation revenue which is only available form 1999, thus it restricts the period of analysis for 2000 onwards when applying first differences.

Instruments must satisfy the following two conditions:

- Instrument exogeneity: The variables we choose as instruments need to be uncorrelated with the model's error term.
- Instrument relevance: The instrument in consideration must be highly correlated with the endogenous variable.

Table 6: IV estimates of the full period

```
. ivreg2 DLGDP DLGov DLinV DLexp crisisdummy (DLCons DLimp = DLinc DLproductivity DLearn)
Warning - collinearities detected
Vars dropped:      DLproductivity
```

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics consistent for homoskedasticity only

Total (centered) SS	=	.0177408359	Number of obs =	21
Total (uncentered) SS	=	.0210067687	F(6, 14) =	12.45
Residual SS	=	.0032046816	Prob > F =	0.0001
			Centered R2 =	0.8194
			Uncentered R2 =	0.8474
			Root MSE =	.01235

DLGDP	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
DLCons	1.514031	2.014808	0.75	0.452	-2.43492	5.462981
DLimp	-.8786132	1.777561	-0.49	0.621	-4.362569	2.605343
DLGov	-.1899508	.5644047	-0.34	0.736	-1.296164	.916262
DLinv	.1732692	.1461927	1.19	0.236	-.1132632	.4598016
DLexp	.639693	1.081172	0.59	0.554	-1.479364	2.75875
crisisdummy	-.0098698	.0192586	-0.51	0.608	-.0476159	.0278763
_cons	.0004659	.0043809	0.11	0.915	-.0081206	.0090524

Underidentification test (Anderson canon. corr. LM statistic): **0.208**
Chi-sq(1) P-val = **0.6487**

Weak identification test (Cragg-Donald Wald F statistic): **0.070**
Stock-Yogo weak ID test critical values: 10% maximal IV size **7.03**
15% maximal IV size **4.58**
20% maximal IV size **3.95**
25% maximal IV size **3.63**

Source: Stock-Yogo (2005). Reproduced by permission.

Sargan statistic (overidentification test of all instruments): **0.000**
(equation exactly identified)

Instrumented: DLCons DLimp
Included instruments: DLGov DLinV DLexp crisisdummy
Excluded instruments: DLinc DLearn
Dropped collinear: DLproductivity

Looking at LM test statistics, with a p-value of 0.208, we can reject the null hypothesis, meaning the model is well identified. Then the Wald F statistics, show a p-value of 0.070, thus we can reject the null that the instruments are weakly identified at a 1% and 5% confidence

level, implying that the model is not weak. The variable corresponding to productivity was dropped because of endogeneity issues.

Table 7: IV estimates for 2000 to 2016

IV (2SLS) estimation					
Estimates efficient for homoskedasticity only					
Statistics consistent for homoskedasticity only					
			Number of obs =		
			F(6, 10) =		
			Prob > F =		
			Centered R2 =		
			Uncentered R2 =		
			Root MSE =		
Total (centered) SS	=	.0050774982			
Total (uncentered) SS	=	.010553059			
Residual SS	=	.0001127157			
DLGDP_02	Coefficient	Std. err.	z	P> z	[95% conf. interval]
DLCons_02	.3339983	.2664866	1.25	0.210	-.1883059 .8563026
DLimp_02	-.0526687	.1313252	-0.40	0.688	-.3100613 .204724
DLGov_02	.0671605	.1034261	0.65	0.516	-.1355509 .2698719
DLinv_02	.2515614	.0498743	5.04	0.000	.1538095 .3493132
DLexp_02	.112035	.0934504	1.20	0.231	-.0711245 .2951946
crisisdummy	-.0009614	.0038898	-0.25	0.805	-.0085852 .0066624
_cons	.003344	.0018009	1.86	0.063	-.0001857 .0068738

After the referendum vote, consumption contribution to economic growth increased. Meanwhile both government spending and investment reduced its contribution to economic growth. Exports contribution to economic growth increased however, it was followed by an accentuation of imports constraint to economic growth.

Table 6 and table 7 results give us non-significant results, which could possibly mean some issue concerning our conditions has arisen. Thus, we developed another model focusing on changes to internal demand, which is the most important contributor for economic growth. We dealt with endogeneity by using earnings as an instrument for growth and aggregating external demand (Table 8, Table 9 and Table 10). Earnings was used as an IV because we have information for the whole period. The new results are significant and the IV used for consumption satisfies the conditions for a good IV.

Table 8: Estimation results using IV, from 1998 to 2021

. ivreg2 DLGDP DLGov DLinV DLexternal crisisdummy (DLCons= DLearn)

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics consistent for homoskedasticity only

Number of obs = 24
F(5, 18) = 196.60
Prob > F = 0.0000
Centered R2 = 0.9826
Uncentered R2 = 0.9866
Root MSE = .003948

Total (centered) SS = .0215165699
Total (uncentered) SS = .0279904697
Residual SS = .000374028

Underidentification test (Anderson canon. corr. LM statistic): 7.760
Chi-sq(1) P-val = 0.0053

Weak identification test (Cragg-Donald Wald F statistic): 8.601
Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38
15% maximal IV size 8.96
20% maximal IV size 6.66
25% maximal IV size 5.53

Source: Stock-Yogo (2005). Reproduced by permission.

Sargan statistic (overidentification test of all instruments): 0.000
(equation exactly identified)

Instrumented: DLCons
Included instruments: DLGov DLinV DLexternal crisisdummy
Excluded instruments: DLearn

DLGDP	Coefficient	Std. err.	z	P> z	[95% conf. interval]
DLCons	.5521482	.1545787	3.57	0.000	.2491795 .8551169
DLGov	.1584352	.0834151	1.90	0.058	-.0050554 .3219258
DLinv	.2445626	.0441876	5.53	0.000	.1579565 .3311686
DLexternal	.3596345	.0894279	4.02	0.000	.184359 .5349101
crisisdummy	-.0077506	.0051214	-1.51	0.130	-.0177883 .0022872
_cons	.0000621	.0013807	0.04	0.964	-.002644 .0027681

Underidentification test (Anderson canon. corr. LM statistic): 7.760
Chi-sq(1) P-val = 0.0053

Table 9: Estimation results using IV, from 1998 to 2018

. ivreg2 DLGDP_01 DLGov_01 DLinV_01 DLexternal crisisdummy (DLCons_01= DLearn_01)

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics consistent for homoskedasticity only

Number of obs = 19
F(5, 13) = 59.07
Prob > F = 0.0000
Centered R2 = 0.9575
Uncentered R2 = 0.9808
Root MSE = .003373

Total (centered) SS = .0050899045
Total (uncentered) SS = .0112672436
Residual SS = .0002161402

DLGDP_01	Coefficient	Std. err.	z	P> z	[95% conf. interval]
DLCons_01	.6124045	.2167916	2.82	0.005	.1875009 1.037308
DLGov_01	-.0166578	.1045979	-0.16	0.873	-.2216659 .1883503
DLinv_01	.2246448	.051254	4.38	0.000	.1241888 .3251009
DLexternal	.3403452	.104346	3.26	0.001	.1358309 .5448595
crisisdummy	-.0021002	.0038366	-0.55	0.584	-.0096199 .0054195
_cons	.0025058	.0021673	1.16	0.248	-.001742 .0067536

Underidentification test (Anderson canon. corr. LM statistic): 8.529
Chi-sq(1) P-val = 0.0035

Weak identification test (Cragg-Donald Wald F statistic): 10.590
Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38
15% maximal IV size 8.96

Table 10: Estimation results using IV, from 1998 to 2016

```
. ivreg2 DLGDP_02 DLGov_02 DLinV_02 DLexternal crisisdummy (DLCons_02= DLearn_02)
```

IV (2SLS) estimation

Estimates efficient for homoskedasticity only
Statistics consistent for homoskedasticity only

Total (centered) SS	=	.0050774982	Number of obs =	17
Total (uncentered) SS	=	.010553059	F(5, 11) =	59.14
Residual SS	=	.0001837839	Prob > F	= 0.0000
			Centered R2	= 0.9638
			Uncentered R2	= 0.9826
			Root MSE	= .003288

DLGDP_02	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
DLCons_02	.5288737	.2562491	2.06	0.039	.0266348	1.031113
DLGov_02	.0324544	.1292703	0.25	0.802	-.2209106	.2858195
DLinV_02	.2459639	.0609453	4.04	0.000	.1265132	.3654146
DLexternal	.3273439	.1120817	2.92	0.003	.1076678	.54702
crisisdummy	-.0019957	.0037781	-0.53	0.597	-.0094005	.0054092
_cons	.0026295	.0021637	1.22	0.224	-.0016114	.0068703

Underidentification test (Anderson canon. corr. LM statistic): 6.437
Chi-sq(1) P-val = 0.0112

Weak identification test (Cragg-Donald Wald F statistic): 6.703
Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38
15% maximal IV size 8.96
20% maximal IV size 6.66

	Table 10	Table 9	Table 8
	1998-2016	1998-2018	1998-2021
Consumption	0.5289**	0.6124***	0.5521***
Government spending	0.0315	-0.0167	0.1584*
Investment	0.2459***	0.2246***	0.2445***
External demand	0.3273***	0.3403***	0.3596***
Crises dummy	-0.0019	-0.0021	-0.0077
Constant	0.0026	0.0025	0.0001

The estimation results from Table 8 to Table 10 give significant results, and have condensed the conclusions taken previously from Table 6 and Table 7, where after the referendum: consumption was sustaining economic growth with a growing significant contribution (from table 10 to table 8, there was an increase of 0.0835pp contribution to economic growth); investment diminished its contribution to economic growth (from table 10 to table 8, there was

an decrease of 0.0213pp to economic growth); government spending was not significant for economic growth. However, in this estimation the contribution to economic growth by external demand increased and the estimator is consistent.

Annex III – Description of effects by dimension and component

Components	Internal Demand	Components	External Demand
Consumption	Negative expectations and uncertainty → Sterling Pound depreciation → Inflation → lower real wage and lower household disposable income → Stagnation of consumption	Overall Trade	1) Negative expectations and uncertainty → Sterling Pound depreciation → export cheaper and import expensive → lower trade deficit (short run) 2) Imports more expensive → Inflation
Government Spending	1) Negative expectations and uncertainty → Sterling Pound depreciation → Inflation (lower real wage) → Lower tax revenues prospects, including income tax revenues 2) Uncertainty → rise in risk premium → possibility of higher cost of debt	Trade in Services	1) Same effects as overall trade 2) Increase of NTB with EU (with TCA) → increase costs to trade; exports growth slowed; imports shift away from EU market → lower service trade surplus (Medium run)
Investment	Negative expectations and uncertainty + future trade costs → decrease in incentives to invest → lower business investment growth	Trade in Goods	1) Same effects as overall trade 2) Increase costs to trade (with TCA) → Diversion of EU to non-EU trade + lower exports with EU (smaller businesses left EU market) ; medium run