International Economics

Master Thesis 2022-2023

The Roaring Twenties for the United Kingdom in the post-Brexit and post-Covid-19 era

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July 14, 2023

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Abstract

The United Kingdom has experienced a tumultuous period caused by the rapid turnover of various prime ministers, the death of Queen Elizabeth, the Covid-19 pandemic and Brexit. This last event is the focus of this thesis, as it aims to estimate the short-term macroeconomic consequences of Brexit on the UK's economy. By utilising a Vector-Autoregression Model the relationship between the nominal GDP growth and deterministic economic variables (oil price, gold price and exchange rate) is examined. The results indicate a change in the relationship between the nominal GDP growth and the exchange rate. Additionally, the effect of Brexit on inflation, household consumption, real GDP growth, government spending, balance of trade and the unemployment rate are investigated by the use of various regression models. The results suggest that Brexit decreased inflation, household consumption and the unemployment rate. The results also show that Brexit increased government spending and the balance of trade and the effect on real GDP growth remains unclear. The results suggest an overall positive effect on the economy of the United Kingdom. Even though all estimations have been corrected for Covid-19, there is a high risk of biases due to large effect of the pandemic and how drastically lives were changed by it.

Contents

1 Introduction

2022 was marked by significant turmoil for the United Kingdom. The country experienced a series of rapid changes, including the appointment of three different prime ministers. Boris Johnson, who resigned due to Party Gate [1], was succeeded by Liz Truss, who herself resigned after just 45 days in office. Currently, Rishi Sunak holds the position of prime minister. Besides these vastly changing prime ministers, the country mourned the loss of Queen Elizabeth II, who passed away on 8 September at the age of 96. The Queen had long been regarded as a stabilising force in British society. These events unfolded against the backdrop of ongoing challenges caused by the Covid-19 pandemic and the aftermath of Brexit.

Up to now, much research has been done with a focus on Brexit. On the eve of Brexit, many attempts were made to predict and quantify the potential costs and consequences of Brexit. Researchers have tried to construct scenarios that could predict the future economic relations between the UK and other economies and the effect on UK's macroeconomic variables. Almost all of this research on Brexit has been focused on looking forward and estimating the potential effect of Brexit, without knowing the exact trade agreements that would be established. Researchers have dealt with this uncertainty by considering several scenarios, i.e. a "soft Brexit" or a "hard Brexit". In the case of a soft Brexit, the UK continues to be a member of the EU Single Market like other non-EU members of the European Economic Area. A hard Brexit is where the UK trades only under WTO rules like the US or Japan. This has for example been done by Dhingra et al. (2016), Steinberg (2019) and Pandžić (2021).

With the actual agreements now known, it is possible to establish and quantify the short-term effects of Brexit on the UK's economy. This allows for a more realistic assessment of the immediate impact of Brexit on various aspects of the economy. This has led to the following research topic:

What are the short-term macroeconomic consequences of Brexit on the economy of the United Kingdom?

As the trade agreements between the UK, the EU and other economies are now known, this research holds value compared to previous studies that relied on forecasting to determine the potential consequences. The availability of the actual trade agreements removes a large amount of uncertainty when it comes to examining the effect of Brexit. Furthermore, while much research has focused on entering a trade union (e.g. Ter-Matevosyan et al. (2017) and Miller and Spencer (1977)), there is still a limited understanding of the consequences of leaving a trade union. Something that occurs infrequently and received limited attention in academic research. This study will thus make a valuable contribution to the existing literature by examining the consequences of departing from a trade union (namely the EU) on the national economy.

[1] https://www.reuters.com/world/uk/uks-boris-johnson-partygate-scandal-2023-06-15/

The short-term macroeconomic effects will be examined in two ways. Firstly, a Vector Auto-Regression model (VAR) will be used to determine whether structural changes occurred in the post-Brexit period, compared to the pre-Brexit period. This VAR model will focus on the relationship between economic growth and influential economic factors, namely the exchange rate, the gold price and the oil price. Hereafter, a regression model will be utilised to examine the relationship between important macroeconomic variables and Brexit. These variables include inflation, real GDP growth, balance of trade, household consumption, government spending and the unemployment rate. The data that will be used comes from the Bank of England, Office for National Statistics and Eurostat. An important issue that needs to be dealt with, lies in the fact that Brexit and the Covid-19 pandemic have an overlapping time period.

This paper has the following construction; it will start with an extensive literature review to provide the reader with a summary of the research that has been conducted on this topic, followed by an explanation of the methods that will be used. Hereafter, a description of the dataset and variables will be given, followed by the results and lastly the conclusion and discussion will be provided.

2 Literature Review

To provide an overview of the current state of the literature, various topics will be discussed. Firstly, the literature related to Brexit will be discussed, followed by the most important trade partners of the UK. Lastly, the trade agreement between the UK and EU will be examined, explaining whether a soft or hard Brexit has taken place.

2.1 Brexit

A considerable amount of research has been dedicated to exploring the potential effects of Brexit. As most of this research has been conducted prior to the establishment of the trade agreement, various scenarios have been examined. To shed light on the current state of the literature, a summary of this extensive research will be provided here.

One of the first papers related to this topic was written by Dhingra et al. (2016), according to whom the European Union (EU) is the UK's largest trading partner. The UK's EU Membership reduced trade costs and increased trade between the two economies. Prior to joining the European Economic Community (EEC) in 1973, nearly a third of UK trade was with the EEC. In 2014, the remaining 27 EU countries accounted for 45% of UK exports and 53% of imports. EU exports also account for 13% of UK national income. Dhingra et al. (2016) argue that Brexit will lower the UK living standards by increasing trade barriers. The potential reduction in per capita income could exceed any savings from the reduction in fiscal contributions to the EU budget.

To estimate the impact of Brexit on UK trade and living standards, the authors present a model of modern trade volumes based on the latest data from the World Infrastructure and Consumer Database (WIOD). In order to predict the consequences of the UK leaving the EU, assumptions must be made related to changes in trade costs after Brexit. As the shape of a future trade deal between the UK and the EU remained unclear at the time of writing, so did the UK's relations with the EU. To address this issue, Dhingra et al. (2016) examined two scenarios: an optimistic scenario in which trade costs between the UK and the EU are assumed to increase slightly, and a pessimistic scenario in which trade costs increase substantially [2]. They conclude by noting that a soft Brexit will result in a 1.3% fall in average UK incomes and a fall of 2.6% in the case of a hard Brexit.

In a follow-up study, Dhingra et al. (2017) have predicted that the most negative economic impact would occur in the case of a hard Brexit. The authors estimate the welfare effects of Brexit, while focusing on trade and fiscal transfers. By utilising a standard quantitative general equilibrium model, they estimate that the loss due to Brexit for the average household will range between 1.3% (in the case of a soft Brexit) and 2.7% (in the case of a hard Brexit).

In a different study, Chen et al. (2018) examine the degree to which EU regions and countries are exposed to negative trade-related consequences of Brexit. To examine this, they have developed an index of this exposure, which incorporates all effects due to geographically fragmented production processes within the UK, the EU and beyond. Their findings show that UK regions are more exposed than regions in other countries. Only regions in Ireland face exposure similar to some UK regions, while the next most affected regions can be found in Germany, The Netherlands, Belgium and France. Additionally, the authors intend to quantify the shares of regional and national GDP and labour income at risk due to Brexit. The extent to which these risks will materialise, depends on the final trade agreements. In order to deal with measurement issues, Chen et al. (2018) create a measure of regional exposure to Brexit. This measurement builds upon existing literature, using global input-output tables to link trade to value-added. It is found that almost all of UK's regions are systematically more vulnerable to Brexit than regions in any other country.

Due to the longstanding trade integration between the UK and Ireland, Irish regions have similar levels of exposure to Brexit, when compared to the UK regions with the lowest levels of exposure (including London and northern parts of Scotland). The most risk-exposed regions in the EU can all be found in southern Germany, where the levels of risk are typically half of that of any UK or Irish region and one third of that displayed by many UK regions. Lastly, there is a very noticeable economic geography logic to the levels of exposure with north-western European regions, being the most exposed to Brexit, while regions in southern and eastern Europe are barely affected by Brexit in terms of trade linkages.

Another aspect of Brexit relates to foreign direct investments (FDI). Driffield and Karoglou

[2] The former being a soft Brexit and the latter being a hard Brexit

(2019) explore the likely effect of Brexit on FDIs through its possible effect on the benchmark variables that characterise the macroeconomy. In order to examine this, a Markov regime switching structural vector auto-regression (SVAR) framework is utilised, first proposed by Ehrmann et al. (2003). This framework allows for non-linearity in the economic process, while still having an economically intuitive structural form (Ehrmann et al., 2003). By using this Markov regime switching SVAR, it is possible to distinguish between the volatile and stable states of the economy and account for the contemporaneous effect that the frequence of FDI naturally generates. The results suggest that, if Brexit triggers a sterling depreciation in the current economic climate [3], this will fuel a prolonged negative effect on FDI. FDI flows may be positively affected by a sterling depreciation after Brexit only if this event drives the UK economy to a period of highly volatile growth, inflation, interest rate and exchange rates.

Similar to Dhingra et al. (2016), Steinberg (2019) examines the welfare costs of Brexit for UK households. This is done by using a dynamic general equilibrium model with heterogeneous firms, endogenous export participation and stochastic trade costs to quantify the impact of uncertainty regarding post-Brexit trade policies. The results suggest that the total consumption-equivalent welfare cost of Brexit for UK households is between 0.4 and 1.2%, but less than a quarter of a percent of this cost is due to uncertainty.

Jawad and Naz (2019) discuss the effects of the Brexit referendum on the UK economy. This is analysed by using pre-Brexit polling and post-Brexit polling economic data and indicators. The pre-Brexit time period starts on 1 May, 2015 and ends on 23 June, 2016 and their post-Brexit period starts on 24 June, 2016 and ends in 28 December, 2017. The authors focus on three key economic variables: exchange rate (US dollar to GB Pound), gold price and oil price, which are known for their volatile nature and play and important role in economic growth. The authors use a variety of tests: graphical representation, Unit Root Test, Johanson Cointegration test, Granger Causality Test, Vector Auto Regression Test, Impulse Response Function (IRF), Variance decomposition and Generalised Auto-Regressive Conditional Heteroskedasticity (GARCH 1, 1).

Thissen et al. (2020) examine the consequences of Brexit from a different perspective. They delve into the regional implications of Brexit and consider how Brexit will affect the competitive vulnerability or opportunity of industries and/or firms in different regions at the level of NUTS2 regions [4] in Europe and how robust these implications are with respect to different types of Brexit agreements. Their focus is on the competitive position of firms within industry-region-specific networks, including those that cross UK-EU international borders.

The general finding is that within the UK, economically weaker regions are most vulnerable to Brexit, regardless of the post-Brexit UK-EU trade agreement. On the other hand, economi-

[3] At the time of writing, Covid-19 did not occur yet

[4] These are basic regions for the application of regional policies (European Commission, 2022)

cally stronger regions within the UK are relatively less vulnerable to Brexit, and their relative vulnerability is reduced by relatively freer UK-EU trading relationship. Therefore, Brexit is likely to increase UK's regional inequalities. On the contrary, many EU regions show little competitive vulnerability to Brexit, but they are in general relatively more responsive to the nature of the post-Brexit UK-EU trade agreements. However, the EU regions stand to gain more from freer post-Brexit trade agreements.

Pandžić (2021) examines the different scenarios regarding the trade relationship between the UK and the EU post-Brexit by estimating three different models. Similarly to previously discussed papers, different scenarios are analysed. The first model examines the possibility and consequences of reaching a deal under existing arrangements similar to those that the EU has with non-EU countries. The second model looks at the case of a "no-deal" or hard Brexit, where trade agreements will be similar to those under WTO rules. In the third and last model the economy is analysed by using a computable general equilibrium (CGE) model. All of these models suggest that Brexit will change the trade relationship between the UK and EU, and will have a significant impact on the UK's economy.

The research by Pandžić (2021) is based on that of Dhingra et al. (2017). By conducting similar research, Pandžić (2021) finds that it will take much more than a year for the UK and the EU to make any agreement on future trade. Furthermore, it will take decades for the UK to amend existing agreements with other countries. Nevertheless, all available research predicts that the significant disruption in trade links between the two economies will have negative economic consequences for both.

2.2 Trade partners EU and UK

2.2.1 Trade partners UK

According to Office for National Statistics (2020), the top five UK trading partners by total trade in goods, excluding unspecified goods in the first half of 2020 were: the United States, Germany, China, the Netherlands and France. These countries accounted for 46% of UK's total trade in goods. Germany is considered to be the largest EU trading partner for goods import and exports in the first half of 2020. It accounts for 13.4% of UK goods imported and 10.7% of goods exported in the first quarter of 2020. Additionally, UK exported more aircraft and aircrafts parts to France than it did to any other country in the first half of 2020. Lastly, the UK exported more oi to the Netherlands than it did to any other country in the first half of 2020.

2.3 EU-UK Trade and Coorporation Agreement

After negotiating the UK and EU came to a Free Trade Agreement (FTA) [5], which is designed to go further than a traditional FTA and provide a solid basis to preserve the good relationship between the UK and EU. It reflects the fact that the UK is leaving the EU's system of common rules, supervision and enforcement mechanisms, and will no longer enjoy the benefits of the EU's single market. The Trade and Coorporation Agreement (TCA) removes all tariffs and quotas and avoids the alternative of having to resort to WTO rules. However, it is the first major agreement in recent history in which trade barriers are raised, instead of lowered. According to Koopman (2021), it is not expected to lead to another economic shock on top of the pandemic, but these barriers do lead to lost EU-UK trade, missed opportunities, and lower structural growth. Lastly, the TCA is a triumph for those in favour of a hard Brexit. Therefore, the research scenarios that focused on a hard Brexit will be more likely to have produced correct predictions.

Most research on Brexit attempts to forecast the impact of Brexit on the UK economy. However, all these studies try to find a proper way around the uncertainty regarding the shape of the trade agreements. Another similarity between the different studies is the fact that several times a negative impact on the UK economy is predicted, in the case of both a hard Brexit and soft Brexit. However, in most research, the effects will be more severe in the case of a hard Brexit. Based on these papers, it is hypothesised that the short-term effect of Brexit on the UK's economy will be negative as the actual trade agreement lies closer to a hard Brexit than a soft Brexit.

3 Methodology

In order to determine the macroeconomic short-term effect of Brexit on the UK's economy, various analysis will be performed. Firstly, to determine whether the relation between deterministic economic variables and economic growth has changed after Brexit, VAR model will be used to determine the behaviour of these variables pre- and post-Brexit. The pre-Brexit period starts in January 1987 and ends in December 2019. The post-Brexit period starts in January 2020, when the UK officially left the European Union, up to the most recent observation, which is May 2023 [6]. This analysis will focus on the oil price, the gold price and the exchange rate and their effect on economic growth, as suggested by Sari et al. (2010), Farzanegan and Markwardt (2009), Tang et al. (2010), Beckmann et al. (2019), Al-Ameer et al. (2018), Auboin and Ruta (2013) and Obansa et al. (2013). This methodology is based on the research of Jawad and Naz (2019) combined with that of Obansa et al. (2013). Economic growth will be measured by the percentage growth of the nominal GDP. The results will be portrayed by the use of orthogonalised impulse response functions (OIRFs).

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:4499829

[6] Or March 2023 for some variables.

After estimating the VAR model, other macroeconomic variables will be examined based on an Ordinary Least Squares regression (OLS). These variables include inflation, household consumption, government spending, real GDP, balance of trade and unemployment rate. In these regression models, various explanatory and control variables will be used based on economic reasoning and previous research.

3.1 Vector Auto-Regression Model

The effect of Brexit on the UK's economy can be examined by using a VAR model. This is a statistical model, often used to capture and analyse the relation and dynamics between multiple time series variables. It allows one to understand how changes in one variable affect the other variables in the system over time. Additionally, in a VAR model the current value of each variable is based on its own lagged values combined with the lagged values of all other variables in the system. It is therefore able to capture the interdependencies and feedback mechanisms between the different variables in the system (Holden, 1995). This VAR will be used to examine the effect of exchange rate, oil price and gold price on economic growth in the period before and after Brexit. In mathematical format, the estimated VAR will look the following way:

$$\begin{aligned} EconomicGrowth_t = \alpha_{ij} + \sum_{j=i}^{k} \beta_{ij} EconomicGrowth_{t-j} \\ + \sum_{j=i}^{k} \lambda ij ExchangeRate_{t-j} + \sum_{j=i}^{k} \theta_{ij} GoldPrice_{t-j} + \sum_{j=i}^{k} \gamma_{ij} OilPrice_{t-j} + \mu_t \end{aligned} \tag{1}$$

$$\begin{aligned} ExchangeRate_t = \alpha_{ij} + \sum_{j=i}^{k} \beta_{ij} EconomicGrowth_{t-j} \\ + \sum_{j=i}^{k} \lambda ij ExchangeRate_{t-j} + \sum_{j=i}^{k} \theta_{ij} GoldPrice_{t-j} + \sum_{j=i}^{k} \gamma_{ij} OilPrice_{t-j} + \mu_t \end{aligned} \tag{2}$$

$$\begin{aligned} GoldPrice_t = \alpha_{ij} + \sum_{j=i}^{k} \beta_{ij} EconomicGrowth_{t-j} \\ + \sum_{j=i}^{k} \lambda ij ExchangeRate_{t-j} + \sum_{j=i}^{k} \theta_{ij} GoldPrice_{t-j} + \sum_{j=i}^{k} \gamma_{ij} OilPrice_{t-j} + \mu_t \end{aligned} \tag{3}$$

$$\begin{aligned} OilPrice_t = \alpha_{ij} + \sum_{j=i}^{k} \beta_{ij} EconomicGrowth_{t-j} \\ + \sum_{j=i}^{k} \lambda ij ExchangeRate_{t-j} + \sum_{j=i}^{k} \theta_{ij} GoldPrice_{t-j} + \sum_{j=i}^{k} \gamma_{ij} OilPrice_{t-j} + \mu_t \end{aligned} \tag{4}$$

Here, the dependent variables indicated with a subscript t, represent the current value of that variable. The variables indicated with subscript $t-j$, represent the lagged value of that variable. Additionally, α_{ij} represents the intercept of the variable and μ_{ij} is the error term.

To produce robust results, the stationarity of the data and the stability of the model need to be verified. To test stationarity, the Augmented Dickey-Fuller test (ADF-test) will be applied (Dickey and Fuller, 1979). Additionally, tests for Granger causality (Granger, 1969) will be utilised to determine whether all variables included have added value in estimating the effect. This will be combined with testing for stability in the model, as suggested by Lütkepohl (2005) and Hamilton and Susmel (1994).

The stability of a VAR is an important aspect of providing a reliable estimation. If a VAR is stable, it is invertible and has an infinite-order vector moving-average representation. In that case, the impulse-response functions and forecast-error variance decomposition [7] can be interpreted. The stability of the VAR can be determined based on the modulus of the eigenvalue [8]. Both Lütkepohl (2005) and Hamilton and Susmel (1994) show that if the modulus of the eigenvalue is strictly less than one, the estimated VAR can be considered stable.

Besides these assumptions, another important aspect of a VAR model, is the lag length selection. This is chosen based on the Schwarz-Bayesian Information Criterion (SBIC) (Schwarz, 1978). Based on the SBIC, a lag length of one is chosen. This lag-selection will be used to determine the OIRFs in both the pre- and post-Brexit sample. It will also be used to determine the stability and Granger causality in the model.

3.2 Covid-19 and Brexit

As Brexit and Covid-19 occurred in a similar time period, it might be difficult to filter out the so-called "pure" Brexit effect. The VAR should therefore be controlled for the effect of Covid-19. Lenza and Primiceri (2022) examined a way to estimate a VAR after March 2020. They explicitly model the change in shock volatility to account for the exceptionally large macroeconomic innovations during the period of the pandemic. This is done by re-scaling the standard deviation of March shocks by an unknown parameter $\bar{s}_0$ and applying the same method for April and May with the parameters $\bar{s}_1$ and $\bar{s}_2$. The following step is to model the likely future evolution of the residual variance, beyond May 2020.

Another approach is presented by Ng (2021), who assumes that Covid-19 is not an economic shock, but a large and persistent health shock with pervasive economic consequences. In this way, the variations in the post-Covid-19 economic data are not mainly caused by changes in distribution of variables in the economic model, but because the economic data are no longer driven by economic shocks alone. In order to address the issues, Ng (2021) uses Covid-19 indicators as controls in regressions to "de-Covid" the data, or as additional predictors

[7] As no forecast is made here, this will not be provided as part of the results.

[8] Eigenvalues are a special set of scalars associated with a linear system of equations. It is a scalar value that represents the amount by which a matrix changes when it is multiplied by a vector. It represents how much a system is "shrinking" or "stretching" in a certain direction.

to account for the persistent nature of Covid-19. The following three measures are used: hospitalisation, positive cases and deaths. Additionally, a time dummy D_t is included for the month March, which is thus modelled as a pure Covid-19 shock.

In this set-up, Covid-19 creates a shock for a variable in $n+t$-th period. Dynamic responses to economic shocks can be obtained by directly or indirectly removing the Covid-19 variations prior to the VAR estimation, and thus assuming that Covid-19 is exogenous. Schorfheide and Song (2021) try to find a method that can deal with Covid-19 in the case of predicting a VAR. They use a mixed-frequency VAR to generate macroeconomic forecasts for the US during the Covid-19 pandemic in real time. They show that excluding a few months of extreme observations is a promising way of handling VAR estimation going forward, as an alternative of a sophisticated modeling of outliers. Due to the close timing of Brexit and Covid-19, dropping observations for the months shortly after Covid-19 hit, will largely bias the dataset and remove part of the pure Brexit effect along with the Covid-19 effect.

The proposed methodology of Schorfheide and Song (2021) is not feasible in this case, due to the close proximity of Covid-19 and Brexit. Removing the observations containing the most extreme observations may result in (partly) eliminating the Brexit effect. Due to similar reasons, the approach of Lenza and Primiceri (2022) cannot be used either. By modelling the increased volatility post March 2020, some components of the Brexit effect may be lost within the model. As a result, the method proposed by Ng (2021) will be used. This will be done by incorporating the proposed control measures as an exogenous shock.

3.3 Augmented Dickey-Fuller test

A stationary time series is one whose properties do not depend on the time at which the series is observed. Stationarity refers to the property of a time series where the statistical properties such as mean, variance, and autocorrelation do not change over time. In general, stationary time series do not have predictable patterns in the long-term and time series that do contain a trend, are considered to be non-stationary. A stationary time series is needed for better predictions. The presence of stationarity in time series can be tested by applying the ADF-test (Dickey and Fuller, 1979). This tests whether a unit root is present in the autoregressive time series. The ADF-test can be represented mathematically as

$$Y_t = \mu + \alpha Y_{t-1} + u_t, \qquad\qquad t = 1, 2, 3, ...$$

The value of α will determine whether a unit root is present. In order to examine the presence of a unit root, the following regression will be estimated

$$\Delta Y_t = (\alpha - 1)Y_{t-1} + u_t = \rho Y_{t-1} + u_t$$

where Δ represents the first difference and $\rho \equiv \alpha - 1$. The time series of Y_t is considered stationary if $\rho < 0$ or (similarly) if $|\alpha| < 1$. If this is not the case, and the time series is non-stationary, the its variance will increase in t. If $|\alpha| > 1$ or $\rho > 0$, the time series is often referred to as a random walk. In this test, the null hypothesis states that a unit root is present, which is the case if $\alpha = 1$ or $\rho = 0$, and the alternative hypothesis states that the time series is stationary or trend-stationary. This is the case if $\alpha \neq 1$ or $\rho \neq 0$.

3.4 Granger Causality

In order to validate the use of a VAR model, Granger causality is tested between all variables. The Granger causality test (Granger, 1969) is a statistical test which is used to determine whether one time series is useful in forecasting another time series. If variable α evolves over time, this variable Granger-causes another variable β if predictions of β based on its own lagged variables and that of α provide a better prediction of β compared to predictions of β based on its own lagged variables.

3.5 Ordinary Least Squares Regression

To determine the effect of Brexit on important macroeconomic variables, a regression analysis will be performed. This will be done for inflation, real GDP, government spending, household consumption, balance of trade and unemployment rate. The explanatory variables that will be added, are based on economic theory and previous research. If a variable contains negative values, it will be standardised by subtracting the mean and dividing by the standard deviation. This method is chosen over log-transformation as many of the variables contain negative values, which would be lost in that case. This is indicated by Ω in the model. If the variable does not contain negative values, it will be log-transformed. Additionally, in all regression equations the variables are provided with a time indicator, to clarify that no lagged variables are used here. Lastly, all variables use data of the UK only.

In the case of inflation, Lim and Sek (2015) proposed the following determinants of inflation: GDP growth, imports, money supply and government spending. The authors focus on the difference in determinants for low inflation and high inflation countries. However, as the time period used here experiences both, all variables will be included, combined with wage growth, interest rate and exchange rates. The growth rate of wages is included as it can capture the effect of labour market dynamics on inflation. The interest rate is included to examine the effect of monetary policy on inflation. Lastly, exchange rates can affect inflation as it captures the the impact of currency movement on inflation. The money supply will be represented by the M3 growth rate, which is defined as the monetary liabilities of euro-area monetary financial institutions and central government vis-à-vis non-MFI euro-area residents, but excluding central government in all currencies (Bank of England, 2023a).

$$
\begin{aligned}
\Omega(Inflation)_t = \beta_0 + \beta_1 Brexit_t + \beta_2 \Omega(RealGDPgrowth)_t + \beta_3 \log(Import)_t \\
+\beta_4 \log(GovernmentSpending)_t + \beta_5 \Omega(M3)_t + \beta_6 \Omega(WageGrowth)_t \\
+\beta_7 \log(InterestRate)_t + \beta_8 \log(ExchangeRate)_t \\
+\beta_9 Recession_t + \beta_{10} War_t + \beta_{11} \Omega(PositiveCases)_t + e_t
\end{aligned}
\tag{5}
$$

In case of household consumption, the research by Varlamova and Larionova (2015) will be followed. Therefore the following variables are included when estimating the effect of Brexit on household consumption: disposable income of households, government spending, inflation and interest rates. Additionally, the unemployment rate will be added to reflect the stability of the income. Inflation is included as this can cause households to consume less in periods of high inflation. Household income on the other hand is likely positively correlated with household consumption; if income increases, a household can consume more. In the case of interest rate, a lower interest rate likely increases borrowing by households. This will increase their disposable income and thus can increase their consumption. Lastly, in line with Keynes' absolute income hypothesis (Keynes, 1939), government spending will increase real disposable income, and thus consumption will increase.

$$
\begin{aligned}
\log(HouseholdConsumption)_t = \beta_0 + \beta_1 Brexit_t + \beta_2 \Omega(Inflation)_t \\
+\beta_3 \log(HouseholdIncome)_t + \beta_4 \log(GovernmentSpending)_t \\
+\beta_5 \log(InterestRate)_t + \beta_6 \log(UnemploymentRate)_t \\
+\beta_7 Recession_t + \beta_8 War_t + \beta_9 \Omega(PositiveCases)_t + e_t
\end{aligned}
\tag{6}
$$

In the research by Schorfheide and Song (2015), inflation, unemployment rate and the interest rate are used to predict the path of GDP growth. Maccarrone et al. (2021) draw from this research and that of Ang et al. (2006), Diebold et al. (2006) and Koop (2013). By doing so, Maccarrone et al. (2021) use the yield curve, inflation, unemployment rate and interest rate, among others to predict the U.S. GDP. When the economy is growing (and GDP is thus increasing), this can put upward pressure on prices, leading to inflation. As demand increases, demand for labour increases as well. However, the supply of labour remains unchanged. This will cause wages to increase, thereby increasing costs and thus prices. This will lead to higher inflation. As the labour demand increases in an expanding economy, the unemployment rate is also likely to decrease. The yield curve is included when estimating the Brexit effect on real GDP growth, as the yield curve is one of the most powerful predictors of economic growth, inflation and recession (Estrella and Mishkin, 1998). Lastly, when the interest rate is low, it is cheaper to borrow money. This will increase consumption and investments, causing the economy to expand. In line with the previously mentioned research and the provided economic reasoning, the following variables will be used in the regression model of real GDP: the yield curve, inflation, unemployment rate and interest rate. In line with Ang et al. (2006) the longest maturity yield is used.

$$\begin{aligned}\Omega(RealGDPgrowth)_t = \beta_0 + \beta_1 Brexit_t + \beta_2\Omega(Inflation)_t + \beta_3\Omega(YieldCurve)_t \\ +\beta_4\log(InterestRate)_t + \beta_5\log(UnemploymentRate)_t \\ +\beta_3 Recession_t + \beta_4 War_t + \beta_5\Omega(PositiveCases)_t + e_t\end{aligned} \tag{7}$$

Government spending is often seen in the light of fiscal policy, which will be the case here as well. In their research, Mawejje and Odhiambo (2022) find that fiscal policy is affected by GDP growth, current account balance, interest rate, inflation and government debt. The same methodology will be applied in the regression model of government spending. Government debt is included as this is likely to strongly affect the government spending. If a government has a higher debt, it will be more difficult to spend and more likely to cut back. Additionally, if the interest rate is low, it is cheaper for a government to borrow money to increase its spending. The current account is a measure of the country's balance of payments with the rest of the world in trade, primary income and secondary income. A positive current account thus means a surplus in budget, which can be used for government spending. The unemployment rate is included, as high unemployment may trigger government spending by reducing taxes, increasing investments by the government or increasing governmental aid. Lastly, if a government wants to increase it spending, it might sell bonds or borrow from other countries. A stronger currency in the home country can cause more demand for the government bonds in the home country. It may be easier for governments to attract additional funding in those cases. This reasoning combined with the provided literature results in the following regression equation:

$$\begin{aligned}\log(GovernmentSpending)_t = \beta_0 + \beta_1 Brexit_t + \beta_2\Omega(RealGDP)_t \\ +\beta_3\Omega(CurrentAccount)_t + \beta_4\log(InterestRate)_t + \beta_5\log(GovernmentDebt)_t \\ +\beta_6\log(UnemploymentRate)_t + \beta_7\log(ExchangeRate)_t \\ +\beta_8 Recession_t + \beta_9 War_t + \beta_{10}\Omega(PositiveCases)_t + e_t\end{aligned} \tag{8}$$

In the case of estimating the effect of Brexit on trade, the balance of trade will be examined. This is defined as exports minus imports. In this model, a proxy for trade openness will be used. This proxy is taken from Malefane (2018) and is defined as the ratio of total trade (import and export combined) and nominal GDP. This proxy for trade openness is included as openness to trade will have a direct effect on the balance of trade. It can namely increase (or decrease) both imports and exports. Weerasinghe and Perera (2019) have identified the effect of GDP and inflation on the balance of trade. Additionally, Muhammad (2010) found that domestic household consumption and real effective exchange rate, among others, significantly affected the trade deficit. In order to determine the effect of Brexit on UK's balance of trade, the GDP, inflation, household consumption, exchange rate and proxy for openness to trade will be used.

$$\begin{aligned}\Omega(BalanceofTrade)_t = \beta_0 + \beta_1 Brexit_t + \beta_2 \Omega(RealGDP)_t + \beta_3 \Omega(Inflation)_t \\ +\beta_4 \log(ExchangeRate)_t + \beta_5 TradeProxy_t + \beta_6 Recession_t + \beta_7 War_t \\ +\beta_8 \Omega(PositiveCases)_t + e_t\end{aligned} \tag{9}$$

As argued by Friedman (1968) and Phelps (1968), unemployment is related to the expected inflation in the expectations-augmented Phillips curve. Therefore, to analyse the effect of Brexit on the unemployment rate, inflation will be included. Additionally, wage growth will be added to the model. If wages increase, more people would want to work, increasing labour supply while labour demand remains unchanged. This will thus increase unemployment, as supply becomes larger than demand. The interest rate will be included as well. If the interest rate is lower, it is cheaper for people to borrow money and they might work less. Through the interest rate, monetary policy is included as well. Household consumption will be included in this model, as an increase in consumption causes an increase in aggregated demand, which will lead to a higher production, thereby increasing labour demand and likely decreasing unemployment. In a similar way, government spending will be included, to proxy for fiscal policy. If government spending increases (e.g. due to investments), it can stimulate economic activity and thereby it decreases unemployment. Lastly, real GDP growth is added to include economic growth. In economic downturn, the economy can slow down. This will decrease the aggregate demand, which will decrease labour demand, thereby increasing unemployment.

$$\begin{aligned}\log(UnemploymentRate)_t = \beta_0 + \beta_1 Brexit_t + \beta_2 \Omega(Inflation)_t \\ +\beta_3 \Omega(RealGDP)_t + \beta_4 \log(GovernmentSpending)_t + \beta_5 \log(HouseholdConsumption)_t \\ +\beta_6 Recession_t + \beta_7 War_t + \beta_8 PositiveCases_t + e_t\end{aligned} \tag{10}$$

4 Data

4.1 Dataset

In order to conduct this research, data on trade flows of the UK are required, as well as data on the various macroeconomic variables. Data focusing on import and export can be retrieved from Eurostat (2023), which is available for all Member States and the European Union (with 27 Member States) for a large number of goods. These data are available on a monthly basis, starting in January 2002 up to December 2022. This data is used to produce the descriptive graphs shown in Appendix A.

Data on UK's nominal seasonally adjusted GDP can be retrieved from the Office for National Statistics (2023d). The GDP is given on a quarterly basis, in million pounds. Additionally, the real GDP growth is provided by the OECD (2023), which is given in percentage change on a quarterly basis compared to the previous period. The data on UK's inflation is retrieved from the Office for National Statistics (2023c). This is provided on a monthly basis in percentage changes, compared to 12 months prior. The data on household consumption is retrieved from the Office for National Statistics (2023f) and is defined as "Household final consumption expenditure" and can be used on a quarterly or yearly basis. It is measured in million GBP. Data on unemployment is retrieved from Office for National Statistics (2023l), which is provided on a monthly basis in percentages and starts in January 1971. Data on household income is taken from Office for National Statistics (2023e). This is provided on a quarterly basis in million GBP, starting from 1955Q1 up to 2023Q1. Data on wage growth is retrieved from Office for National Statistics (2023a). The data is provided on a monthly basis in percentages as three month average growth. The data starts in March 2001 and is available up to May 2023.

Data on government spending is taken from Office for National Statistics (2023g) as well. This dataset is also available on a monthly basis, starting from April 1997 and is given in million GBP. Data on government debt is retrieved from Office for National Statistics (2023h) and is provided on a monthly basis in billion GBP. As all other data is provided in million GBP, the data on government debt will be transformed into the same measurement unit. Data on the current account is taken from Office for National Statistics (2023b) as well. Here, the data is provided in million GBP on a quarterly basis, starting from 1955Q1 up to 2023Q1. Data on the yield curve is retrieved from Bank of England (2023d). The data based on the yields on UK government bonds is used, also referred to as gilts. Here, the instantaneous implied forward real rates, short end are used with the longest possible maturity, which is 60 months. This is in line with the research of Ang et al. (2006).

Additional data on import and export is taken from the Office for National Statistics. UK's import trade data is retrieved from the Office for National Statistics (2023k). This dataset is provided on a monthly basis and starts in January 1997. Data on exports is taken from Office for National Statistics (2023j), which is available from January 1997 onwards. Both data for exports and imports are provided in million pounds. Data on import and export is used to create the balance of trade variable. Data on the M3 money supply growth is taken from Bank of England (2023a) and is defined as "monthly 12 month growth rate of monetary financial institutions' sterling and all foreign currency M3 liability to private and public sectors (in percent)". The data is seasonally adjusted. Data on the interest rate is retrieved from Bank of England (2023b). Note that the interest rate is referred to as the "Bank Rate". For the sake of simplicity, the term interest rate will be used here. Data on interest rate provides an observation each time the interest rate is changed by the Bank of England. The gaps in the data are filled by adding the value of the interest rate until another change occurred, to create a monthly dataset. Additionally, if the interest rate changed more than one time during a certain month, the average of these interest rates is used.

Data on exchange rates is taken from the Bank of England (2023c) and starts on 17 January 1975. This data is provided on a daily basis and defined as the spot exchange rate, sterling

Table 1: Descriptive statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum	Measurement Unit
Inflation	315	2.231	1.926	−0.1	11.1	%
Household Consumption	315	288,321	37,496.95	208,783	348 077	£m
Household Income	426	230,744.4	91,319.14	78,799	428,433	£m
Real GDP growth	315	2.338	10.839	-61.032	84.894	%
Nominal GDP	315	474,595.4	55,266.6	361,885	561,480	£m
Balance of Trade	315	−2177.54	2384.41	−14, 245	8733	£m
Exchange rate	315	0.654	0.088	0.483	0.885	£
Unemployment rate	314	5.631	1.322	3.5	8.5	%
Wage growth	267	3.1577	1.8051	−2.7	9.2	%
Government Spending	312	57,280.71	18,885.84	22,943	109,835	£m
Government Debt	363	977,429.2	698,013.1	201,900	2,567,200	£m
Current Account	361	−11, 287.93	9711.48	−50, 455	2349	£m
Interest Rate	315	2.679	2.420	0.175	7.5	%
M3 growth	428	7.254	5.4998	−4.5	18.7	%
Yield	462	1.541	2.1979	−3.2394	5.2137	%
Gold price	315	659.900	426.437	159.717	1575.563	£/troy ounce
Oil price	315	307.555	84.648	169.7	571.2	index

Note. The table provides an overview of descriptive statistics per variable. It it is important to note that the real GDP, and the exchange rate, bank rate and unemployment rate are provided in percentages, where the real GDP is the percentage change compared to 12 months prior.

pound to US dollar. Data on the gold price is taken from World Gold Council (2023). This is also provided on a daily basis and is given in pound sterling per unit troy ounce. Data on the oil price is retrieved from Office for National Statistics (2023i), and is provided on a monthly basis in index format with 1987 as base year.

After combining all different datasets and merging this with data on recessions, Brexit and the conflict between Ukraine and Russia, a dataset with a maximum of 426 observations per variable and 16 variables is established. An overview of these observations is shown in Table 1, along with descriptive statistics.

As Brexit occurred quite simultaneously with the Covid-19 pandemic, data on this is included in the dataset as well. In line with research by Ng (2021), the following three variables are included; hospitalisation, number of positive cases and number of deaths. These data are available on a daily basis and are thus aggregated to a monthly basis, in order to match with the other variables. Data on hospitalisation, number of positive cases and number of deaths are taken all from UK Government 2023c, 2023a and 2023b, respectively. An overview of these variables is provided in Table 2, combined with descriptive statistics.

4.2 Descriptive graphs

To provide more insight into the trade patterns of the UK, various time-series have been plotted per trading partner of the UK. This is done based on data retrieved from Eurostat. All numbers retrieved from Eurostat are given in absolute value in euros. To provide a more interpretable result, all values are transformed into indices, for which 1999m1 is used as the base-year. These

Table 2: Descriptive statistics of Covid-19 variables

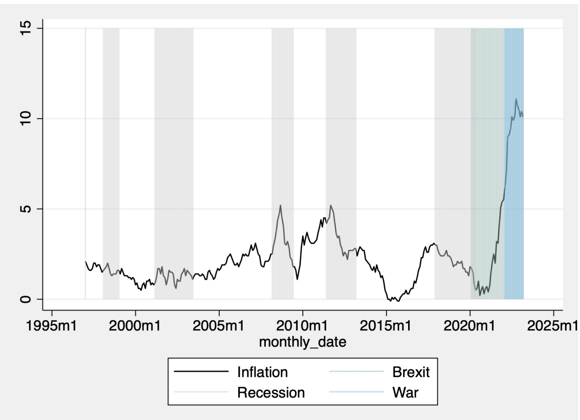
Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Hospitalisation	315	33 551.54	116 986.3	0	1 074 626
Positive cases	305	72410.77	366 738.8	0	3 753 946
Deaths	315	713.4	3401.56	0	36 584

Note. The table provides an overview of descriptive statistics for hospitalisation, positive cases and number of deaths caused by Covid-19.

figures can be found in Appendix A. Furthermore, graphical representations of the variables listed in Table 1 are provided as well. These are denoted in the figures below. Please note that only the variables that are used as dependent variable are shown here. Graphs of the other variables can be found in Appendix B.

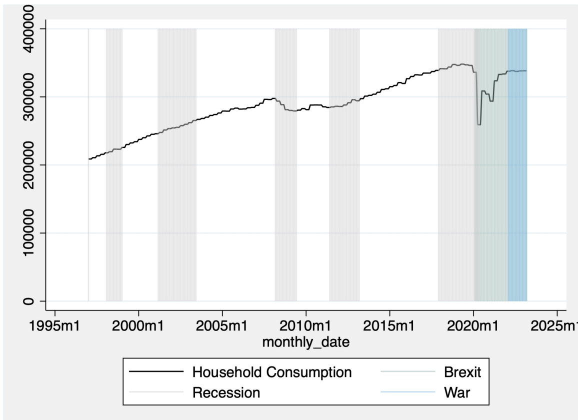
Figure 1 displays the evaluation of inflation over time. One can see that there tends to be a spike when a recession occurs. Observations for this graph start in January 1997 and end in March 2023. Additionally, there is a sharp increase after June 2023. Figure 2 illustrates the development of household consumption over time. Here, the observations start in January 1997 and end in March 2023 and a decline in household consumption can be observed after January 2021, which increases again after May 2021.

Figure 1: Inflation



Note. The graph portrays the development of inflation over time. The data observations start in January 1997 and end in March 2023. One can observe an increase around June 2021.

Figure 2: Household Consumption

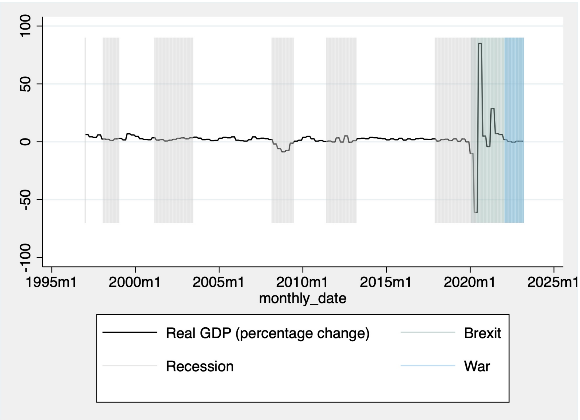


Note. The graph portrays the development of household consumption over time. The data observations start in January 1997 and end in March 2023. One can observe a decrease around January 2021.

The development over time of real GDP growth is shown in Figure 3. A large change is observed in the period from January 2020 until September 2020. These large changes seem to die out after this period and the real GDP growth moves into a more stable phase. The path of the nominal GDP is shown in Figure 4. The development of the nominal GDP over time shows close resemblance to the development of the household consumption as both contain a drop in

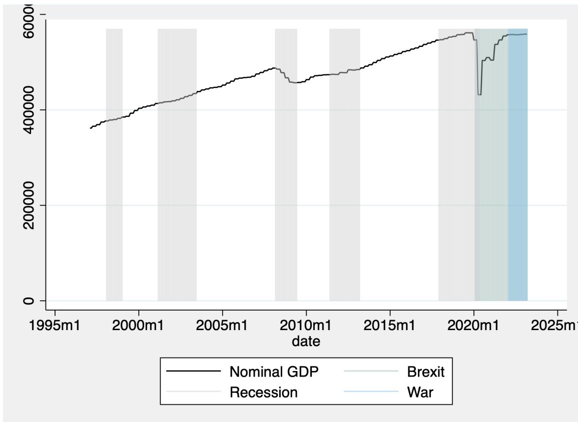
January 2020 and recover gradually afterwards. The nominal GDP seems to be increasing over time.

Figure 3: Real GDP growth



Note. The graph portrays the development of the real GDP growth over time. The data observations start in January 1997 and end in March 2023. It seems to be the case that the volatility of the real GDP growth increases around January 2020 and flattens again after January 2022.

Figure 4: Nominal GDP



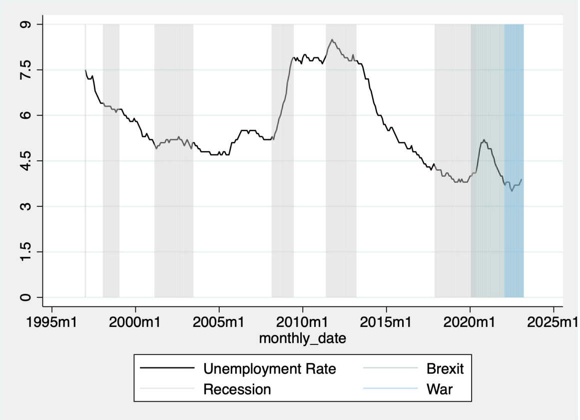
Note. The graph portrays the development of the nominal GDP over time. The data observations start in January 1997 and end in March 2023. A large drop in nominal GDP seems to occur in January 2020. However, the nominal GDP seems to recover quite fast and returns to its original value.

Figure 5 displays the trajectory of the unemployment rate. The unemployment rate experiences its maximum value in October 2011, after which it decreased gradually. However, it remains higher than before. The unemployment rate experiences an increase again in January 2020. This increase was relatively short-lived as the unemployment rate decreased again in December 2020. The development of the balance of trade over time is shown in Figure 6. Volatility in balance of trade seems to increase starting in January 2020 and a large drop occurs in March 2022. However, the balance of trade recovers quite rapidly from this. The balance of trade, however, still experiences a various peaks and drops.

Government spending is shown in Figure 7. Government spending seems to have an upward trend and volatility seems to be high over time. However, a strong increase occurred in April 2020. Observations for government spending start in January 1997 and end in May 2023. Figure 8 displays the development of the exchange rate over time. Here, observations start in January 1997 and end in May 2023. There seems to be a an increase from July 2020 until June 2021, after which the exchange rate decreases again. It also worth mentioning that the exchange rate drops when a regression occurred.

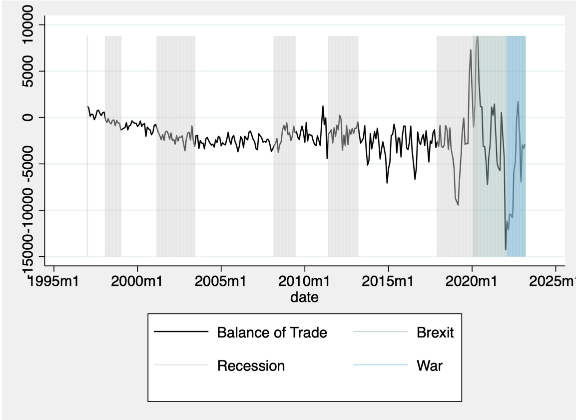
The development of the gold price is shown in Figure 9. One can observe a sharp increase at the moment Brexit occurs. However, this increase seems to be short-lived as it decreases again shortly after. After this, the gold price increases again until the end of the sample. Lastly, the development of the oil price over time is shown in Figure 10. Here, a decrease in oil price is observed at the same time as Brexit occurred. The oil price seems to increase over time

Figure 5: Unemployment rate



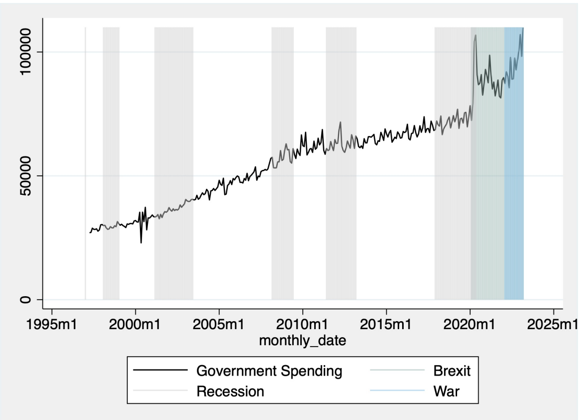
Note. The graph shows the development of the unemployment rate, starting in January 1997 and ending in February 2023. After a period of decline, the unemployment rate starts increasing again in January 2020 and it decreases again in December 2020.

Figure 6: Balance of Trade



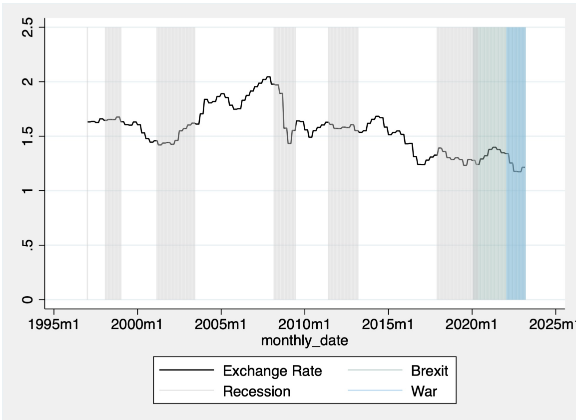
Note. The graph portrays the development of the balance of trade over time. The data observations start in January 1997 and end in March 2023. There are large difference in the balance of trade in January 2020 and at the start of Brexit.

Figure 7: Government Spending



Note. The graph portrays the development of government spending over time. The data observations start in January 1997 and end in March 2023. Government spending seems to have been increasing over time but, a large increase is observed in April 2020.

Figure 8: Exchange Rate



Note. The graph portrays the development of government spending over time. The data observations start in January 1997 and end in March 2023. Government spending seems to have been increasing over time but, a large increase is observed in April 2020.

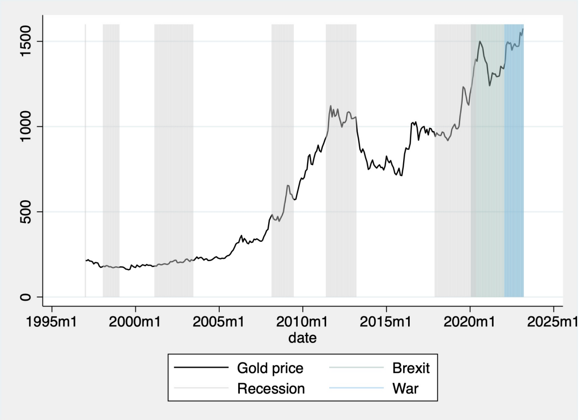
and experiences it maximum value during the Ukraine-Russia conflict, after which it decreases again.

5 Results

5.1 Stationarity and stability

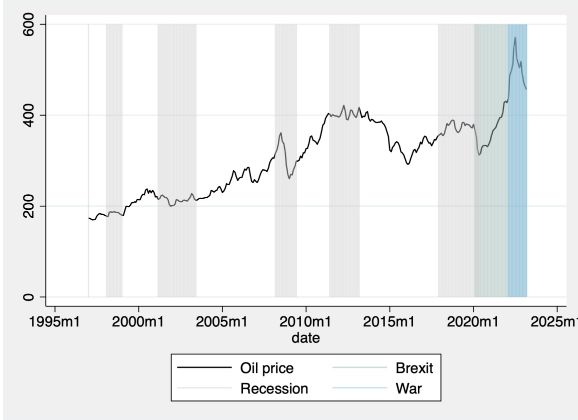
To test whether unit roots are present in the dataset, the ADF-test is used. The ADF-test is performed for both the pre- and post-Brexit sample with one lag and controlling for drift. The results from the pre-Brexit sample are found in Table 3. The second column of the table displays the p-value and the third column shows the corresponding test statistic. The last three

Figure 9: Gold price



Note. The graphs shows the development of the gold price over time, starting in January 1997 and ending in March 2023. An increase in price seems to occur around the same time as Brexit, after which it decreases again. It increases again after a short period of time.

Figure 10: Oil Price



Note. The graph portrays the development of the oil price over time. It starts in January 1997 and ends in March 2023. A large drop occurs shortly after Brexit, but the oil price increases again afterwards, reaching its maximum value during the Ukraine-Russia conflict.

columns show the critical value for the 1%, 5% and 10% significance level, respectively. For all variables, their first difference has been used to remove stationarity from the data. Additionally, the ADF-test is applied on both the pre- and post-Brexit sample. The results for the pre-Brexit sample are provided in Table 3. From these results, it can be deduced that all variables are significantly stationary at the 1% level, when their first differences are used.

Table 3: ADF-test for stationarity in pre-Brexit sample

Variable	**P-value**	**Test statistic**	**Critical value 1%**	**Critical value 5%**	**Critical value 10%**
Oil Price	0.000	-12.607	-2.336	-1.649	-1.284
Gold Price	0.000	-12.821	-2.336	-1.6489	-1.284
Exchange Rate	0.000	-12.938	-2.336	-1.649	-1.284
Growth rate GDP*	0.000	-15.203	-2.340	-1.651	-1.285
Observations	393				

Note. For all variables, their first difference has been used in order to create stationary time series. By doing so, all variables are stationary at the 1% significant level. Compared to the other variables, the GDP growth rate has fewer observations, namely 273 compared to 393 of all other variables.

The results for the post-Brexit sample are provided in Table 4. Here, the first differences of all variables are used as well. The second column of the table displays the p-value and the third column shows the corresponding test statistic. The last three columns show the critical value for the 1%, 5% and 10% significance level respectively. Based on the results, it is concluded that all four variables are significant stationary at the 1% significance level as well.

In order to test whether the variables are stable when used in a VAR model, the moduli of the eigenvalues are considered. The results for both the pre-Brexit and post-Brexit sample are shown in Table 5. If the modulus of the eigenvalue is strictly below 1, the VAR satisfies the stability condition (Lütkepohl (2005) and Hamilton and Susmel (1994)). The first column

Table 4: ADF-test for stationarity in post-Brexit sample

Variable	P-value	Test statistic	Critical value 1%	Critical value 5%	Critical value 10%
Oil Price	0.000	-3.848	-2.429	-1.686	-1.304
Gold Price	0.000	-4.148	-2.429	-1.686	-1.304
Exchange Rate	0.000	-3.918	-2.429	-1.686	-1.304
Growth rate GDP*	0.000	-4.245	-2.434	-1.688	-1.306
Observations	41				

Note. For all variables, their first difference has been used in order to create stationary time series. By doing so, all variables are stationary at the 1% significant level. Compared to the other variables, the GDP growth rate has fewer observations, namely 39 compared to 41 of all other variables.

of the table shows the variable. For all variables, one lag is included. This is in line with the lag-selection based on the SBIC criteria as mentioned before. The second and third column provide the moduli of eigenvalues for the pre-Brexit and post-Brexit sample, respectively. In the pre-Brexit sample, all moduli are below 1. This indicates that the VAR satisfies the stability condition and will thus properly capture the dynamics and produce reliable results. The moduli in the post-Brexit case all have a value below 1 as well. It can therefore be concluded that the model will provide reliable results and effectively captures the dynamics in the model after Brexit.

Table 5: Stability test pre- and post-Brexit sample

Variable	Pre-Brexit	Post-Brexit
Oil Price $(t-1)$	0.993	0.387
Gold Price $(t-1)$	0.412	0.197
Exchange Rate $(t-1)$	0.216	0.197
Growth Rate GDP $(t-1)$	0.216	0.187

Note. Results of stability test for both the pre- and post-Brexit sample. Values presented are the modulus of the eigenvalue, all of which are below 1 and thus both VAR models satisfy the stability condition.

5.2 Granger Causality

In order to determine the decomposition of variables in the VAR, the Granger causality test (Granger, 1969) is used. Granger causality is tested by using the whole sample. The results of this test is provided in Table 6. The variables in the first column (variable α) should be read being "Granger caused" by the variable in the first row (variable β), if the corresponding cell is marked with an x. In those cases, the lagged values of β combined with the lagged values of α provide a better prediction of α than just using the lagged values of α. The variables β are marked as Granger causing variables α at the significance level of 5%. Based on these results, it can be concluded that the growth rate of the nominal GDP is Granger caused by all variables separately and all variables combined. Furthermore, the gold price is Granger caused by the oil price and the exchange rate is Granger caused by the growth rate of nominal GDP.

Table 6: Results Granger causality test VAR variables

Variables α \ Variables β	Exchange Rate	Oil Price	Gold Price	Growth Rate GDP	All Variables
Exchange Rate				x	
Oil Price					
Gold Price		x			x
Growth Rate GDP	x	x	x		x
All Variables					

Note. The table provides the results for the Granger causality test among all variables. It shows that the growth rate of nominal GDP is Granger caused by all variables separately and all variables combined.

5.3 Vector Auto-Regression Model

Here, the results from the VAR based on the OIRFs will be discussed. These are estimated twice, once for the pre-Brexit sample and once for the post-Brexit sample. The OIRFs are provided in graphical and numerical form. The pre-Brexit graphical representation is provided in Figure 11 and the post-Brexit graphical representation is given in Figure 12.

5.3.1 Pre-Brexit

The OIRFs for the oil price, gold price, exchange rate and growth rate GDP for the pre-Brexit sample are provided in the tables below. In these tables a horizon of 10 is provided. The impulse variable is shown in the second column and the response variables are provided in the third, fourth, fifth and sixth column. All coefficients are estimated by using a 95% confidence interval.

The OIRF for oil price is shown in Table 7. Here, the gold price reacts positively to a shock in the oil price in the period of the shock. However, after the first period all values become negative, suggesting that the response of the gold price to a shock in the oil price is negative from the first period after the shock. In case of the response of the exchange rate to a shock in the oil price, the response is negative from the moment the shock occurs until the fifth period. After this period, the shock seems to die out. Lastly, it can be derived that the growth rate of nominal GDP response positive to a shock in oil prices at first, after which the response becomes negative in the first period after the shock. In the second period, the response becomes positive and the growth rate GDP reverts back to normal after seven periods. When considering the graphs in Figure 11, one can observe that in all cases, the confidence interval moves in a similar way as the response values, suggesting that the results are reliable.

The OIRFs of the gold price are shown in Table 8. The results in the second column suggest that the oil price only reacts to a shock in the gold price in the period after the shock. In

Table 7: OIRF of Oil Price; Pre-Brexit sample

		Response Variable			
Horizon	Impulse variable	**Oil Price**	**Gold Price**	**Exchange Rate**	**Growth Rate GDP**
0	Oil Price	6.538	2.014	-0.003	0.020
1	Oil Price	2.621	-1.503	-0.001	-0.001
2	Oil Price	0.105	-1.107	-0.0003	0.004
3	Oil Price	0.434	-0.531	-0.0001	0.001
4	Oil Price	0.179	-0.234	-0.000	0.001
5	Oil Price	0.074	-0.098	-0.000	0.0002
6	Oil Price	0.031	-0.041	0.000	0.0001
7	Oil Price	0.013	-0.017	0.000	0.000
8	Oil Price	0.005	-0.007	0.000	0.000
9	Oil Price	0.002	-0.003	-0.000	0.000
10	Oil Price	0.001	-0.001	-0.000	0.000

Note. The table provides the OIRFs when estimating the pre-Brexit VAR model with one lag for oil price and the responses of oil price, gold price, exchange rate and the growth rate of nominal GDP. The impulse variable is shown in the second column and the horizon is provided in the first column.

that case, the oil price reacts negatively, which remains this way until the seventh period. In the eight period the value becomes slightly positive, only to revert back to negative in the ninth and tenth period. In the case of exchange rate, the response of exchange is positive to a shock in the gold price. This response is however very small and only present in the first three periods. Hereafter the response flattens out. When considering the response of the nominal GDP's growth rate, one can observe that this reacts positively to a shock in oil prices in the period of the shock. In the first period after the shock, the growth rate of the nominal GDP becomes negative, only to become positive again in every period afterwards. The response seems to disappear after seven periods. When considering the plotted OIRFs of the gold price (see Figure 11), the confidence interval for the response of oil price to a shock in gold price contains both positive and negative values, making it difficult to produce reliable results in terms of the gold price's response. In all other cases, the confidence interval moves in a similar way as the OIRF-values.

Table 9 shows the OIRFs of exchange rate. Here, both the oil price and gold price only react after the period of the shock. The response of the oil price to a shock in the exchange rate is positive for the entire horizon, even though the value becomes smaller over time. When considering, however, the form of the confidence interval shown in Figure 11, one can see that the confidence interval covers both positive and negative values. It is thus difficult to determine the actual response of oil price to a shock in exchange rate. The results of the response of the gold price to a shock in the exchange rate show that the gold price reacts positively until the eight period, hereafter the response becomes negative. In this case, the confidence interval moves in a similar way as the response values, suggesting a reliable result. The response of the growth rate of nominal GDP to a shock in the exchange rate suggest that the growth rate of

Table 8: OIRF of Gold Price; pre-Brexit sample

		Response Variable			
Horizon	Impulse variable	**Oil Price**	**Gold Price**	**Exchange Rate**	**Growth Rate GDP**
0	Gold Price	0.000	24.162	0.005	-0.013
1	Gold Price	-0.076	6.134	0.001	-0.033
2	Gold Price	-0.116	1.433	0.0001	-0.001
3	Gold Price	-0.055	0.368	0.0000	-0.002
4	Gold Price	-0.027	0.094	0.0000	-0.0001
5	Gold Price	-0.012	0.028	0.0000	-0.0001
6	Gold Price	-0.0005	0.009	0.0000	-0.0000
7	Gold Price	-0.002	0.003	0.0000	-0.0000
8	Gold Price	0.0001	0.001	0.0000	-0.0000
9	Gold Price	-0.0004	0.0004	0.0000	-0.0000
10	Gold price	-0.0001	0.0002	0.0000	-0.0000

Note. The table provides the OIRFs when estimating the pre-Brexit VAR model with one lag for gold price and the responses of oil price, gold price, exchange rate and the growth rate of nominal GDP. The impulse variable is shown in the second column and the horizon is provided in the first column.

nominal GDP reacts negatively to a shock in exchange rates. After eight periods, the response of GDP's growth rate flattens out again.

Table 9: OIRF of Exchange Rate; pre-Brexit sample

		Response Variable			
Horizon	Impulse variable	**Oil Price**	**Gold Price**	**Exchange Rate**	**Growth Rate GDP**
0	Exchange Rate	0.000	0.000	0.012	-0.041
1	Exchange Rate	0.153	1.992	0.003	-0.006
2	Exchange Rate	0.090	0.857	0.001	-0.004
3	Exchange Rate	0.034	0.257	0.0001	-0.007
4	Exchange Rate	0.013	0.068	0.0000	-0.0003
5	Exchange Rate	0.005	0.015	0.0000	-0.0000
6	Exchange Rate	0.002	0.003	0.0000	-0.0000
7	Exchange Rate	0.001	0.0003	0.0000	-0.0000
8	Exchange Rate	0.0002	-0.0001	0.0000	0.0000
9	Exchange Rate	0.0001	-0.0001	0.0000	0.0000
10	Exchange Rate	0.0000	-0.0000	0.0000	0.0000

Note. The table provides the OIRFs when estimating the pre-Brexit VAR model with one lag for exchange rate and the responses of oil price, gold price, exchange rate and the growth rate of nominal GDP. The impulse variable is shown in the second column and the horizon is provided in the first column.

Table 10 shows the OIRFs of the growth rate of nominal GDP in the pre-Brexit sample. These results show that the oil price, gold price and exchange rate only react to a shock in the growth rate of nominal GDP in the period after the shock. The oil price reacts positively to this shock in all periods, even though the values become smaller each period. The reaction of the gold price to a shock in the growth rate of the nominal GDP is positive in the first period but becomes negative in the second one and remains that way until the last period. Here, the values decrease over time as well. The response of the exchange rate is negative from the first period to the last period. When considering the plotted OIRFs in Figure 11, one can see that the confidence interval moves in a similar way in the case of the oil price and exchange rate.

Table 10: OIRF of growth rate GDP; pre-Brexit sample

		Response Variable			
Horizon	Impulse variable	**Oil Price**	**Gold Price**	**Exchange Rate**	**Growth Rate GDP**
0	Growth Rate GDP	0.000	0.000	0.000	0.380
1	Growth Rate GDP	0.720	0.789	-0.0008	-0.084
2	Growth Rate GDP	0.112	-0.303	-0.0000	0.019
3	Growth Rate GDP	0.082	-0.060	-0.0000	-0.004
4	Growth Rate GDP	0.026	-0.049	-0.0000	0.001
5	Growth Rate GDP	0.012	-0.016	-0.0002	-0.0001
6	Growth Rate GDP	0.005	-0.007	-0.0000	0.0001
7	Growth Rate GDP	0.002	-0.003	-0.0000	0.0000
8	Growth Rate GDP	0.0001	-0.001	-0.0000	0.0000
9	Growth Rate GDP	0.0004	-0.0005	-0.0000	0.0000
10	Growth Rate GDP	0.0001	-0.0001	-0.0000	0.0000

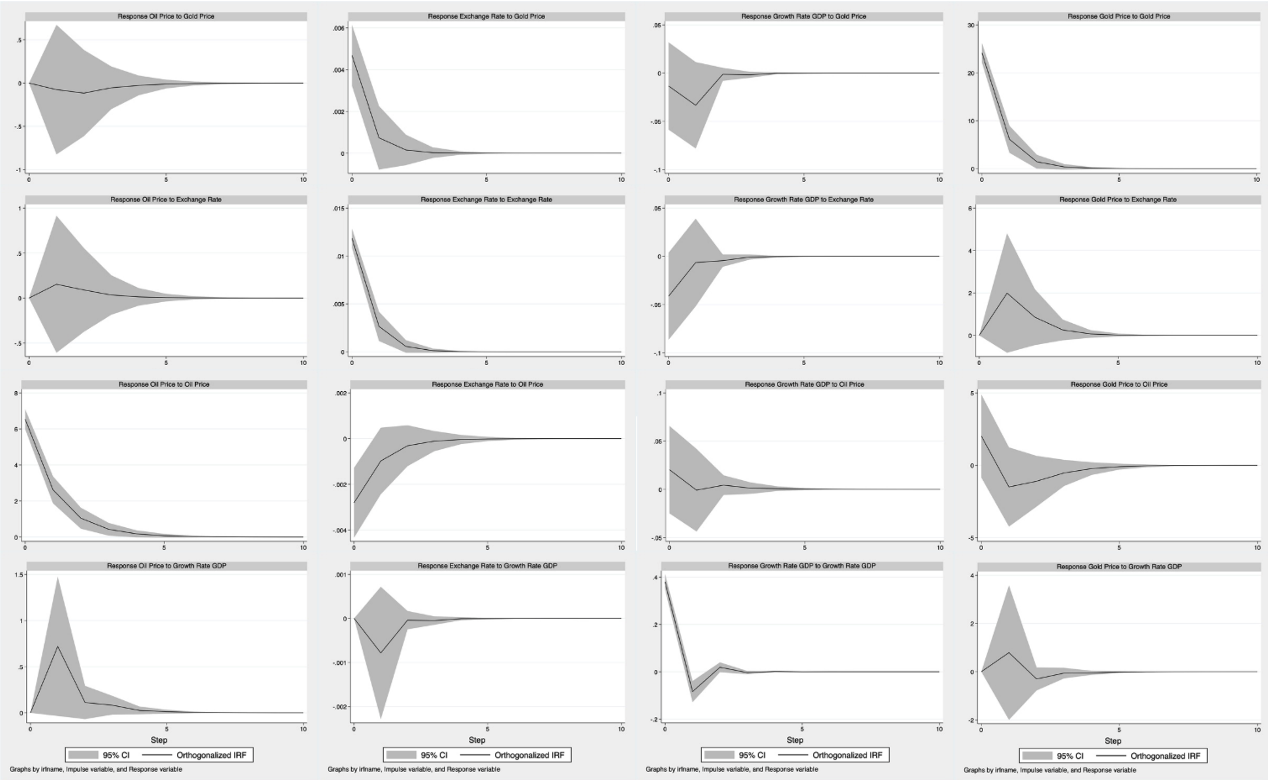
Note. The table provides the OIRFs when estimating the pre-Brexit VAR model with one lag for the growth rate of nominal GDP and the responses of oil price, gold price, exchange rate and the growth rate of nominal GDP. The impulse variable is shown in the second column and the horizon is provided in the first column.

As noted before, some estimations do not hold large statistical power. For example, the response of oil price to a shock in the gold price. Here, results have no actual meaning as the confidence interval contains both positive and negative values, making it (almost) impossible to draw any conclusions regarding the response of oil prices to a shock in gold prices. The same holds when considering the response of oil price to exchange rate. Here, the confidence interval covers both negative and positive values, making it difficult to conclude on the response of oil price to a shock in exchange rate.

In the reversed case, when gold price responds to a shock in oil price, one can see that the gold price responds negatively to a shock in oil price. Here, the confidence interval moves in the same direction, indicating that there is sufficient statistical evidence to draw this conclusion. Similarly, when considering the response of exchange rate to a shock in oil price, the exchange rate responds negatively to this shock and the shock dies out after five periods.

As the response of the growth rate of nominal GDP is of interest here, its response to a shock in gold price, oil price and exchange rate will be summarised. In case of the oil price, GDP's growth rate reacts positively in the period of the shock, only for it to become negative in the first period after the shock. From the third period until the sixth period the response remains

Figure 11: Plotted OIRFs; pre-Brexit sample



Note. The figure represents the various impulse response functions in the pre-Brexit sample. A VAR(1) model is estimated by using OLS over the sample January 1997 to March 2023. The 95% confidence interval is used.

positive, after which the response flattens out. If the plotted OIRF in Figure 11 is considered, one can observe that the confidence interval moves in a similar way as the estimated value, and thus produced a reliable result. In case of the gold price, the growth rate of the nominal GDP reacts negatively in all periods to a shock in the gold price. This is also substantiated by the plotted OIRF in Figure 11. This can be explained by the fact that gold is often referred to as a "safe" investment in times of economic uncertainty. The growth of nominal GDP is therefore likely lower when the gold price is higher. The same reaction holds in case of a shock to the exchange rate. The growth rate of nominal GDP reacts negatively to a shock in exchange rate in from the period of the shock to the seventh period. Hereafter, the shock flattens out. The response becomes slightly less negative in each period, which is also supported by the plotted OIRF in Figure 11.

5.3.2 Post-Brexit

Here, the OIRFs of the oil price, gold price, exchange rate and growth rate of nominal GDP in the post-Brexit sample are provided. The graphical representation of these OIRFs are shown in Figure 12. These tables have the same lay-out as the pre-Brexit OIRF tables, only is the horizon in the post-Brexit sample provided from 0 to 8 instead of 0 to 10.

The OIRFs of the oil price are shown in Table 11. Based on this table, one can see that the gold price responds strongly positive to a shock in oil prices in the period of the shock. In the first period this reaction becomes slightly negative and moves closer to zero afterwards, after which the value starts shifting between a small negative and positive value in period four. Eventually, the response flattens out again. When considering the plotted OIRF (see Figure 12), it is observed that the confidence interval moves in a similar way as the response values, suggesting that this estimation is reliable. Furthermore the exchange rate reacts positively in the period of the shock and the first period after the shock. Hereafter, the response becomes negative and dies out shortly after. The confidence interval moves in a similar way as well, suggesting a reliable result. Lastly, based on the results in the last column, it can be concluded that the growth rate of nominal GDP responds negatively in the first two periods, and then fluctuates between positive and negative until it flattens out again.

Table 11: OIRFs of Oil Price; post-Brexit sample

Horizon	Impulse variable	Response Variable			
		Oil Price	**Gold Price**	**Exchange Rate**	**Growth Rate GDP**
0	Oil Price	8.445	15.933	0.002	0.268
1	Oil Price	-1.138	-0.704	0.002	-0.218
2	Oil Price	-0.660	-1.224	-0.0001	-0.207
3	Oil Price	0.057	-0.331	0.0001	0.060
4	Oil Price	-0.0004	0.053	-0.0000	-0.015
5	Oil Price	0.006	-0.011	0.0000	0.006
6	Oil Price	-0.004	0.004	0.0000	-0.003
7	Oil Price	0.001	-0.003	0.0000	0.001
8	Oil Price	-0.0003	0.001	0.0000	-0.0004

Note. The table provides the OIRFs when estimating the post-Brexit VAR model with one lag for oil price and the responses of oil price, gold price, exchange rate and the growth rate of nominal GDP. The impulse variable is shown in the second column and the horizon is provided in the first column.

The response of the various variables to a shock in the gold price are shown in Table 12. Here, one can see that the oil price only reacts to a shock in the gold price one period later. This response is negative and becomes positive again in the next period. The fluctuations become smaller each time until it eventually dies out. However, when considering the confidence interval (see again Figure 12), it is observed that it includes both positive and negative values. The estimated results are thus not reliable when suggesting the response of oil price to a shock in the gold price. The exchange rate reacts negatively to a shock in the gold price and stays negative in period 0 and 1. After these periods the response becomes smaller and flattens out shortly after. Here, the confidence interval, as shown in Figure 12, moves in a similar way as the estimated values. The estimated results are thus reliable when examing the response of the exchange rate to a shock in the gold price. Lastly, one can see that the growth rate of nominal GDP responds positively to a shock in the gold price immediately. However, after 5 periods the shock dies out. Here, some type of "ripple" response seems to occur. This same ripple effect is also portrayed by the OIRF, in Figure 12, where the confidence interval moves in a similar way. It is thus a reliable estimation that GDP's growth rate responds as suggested by the values in Table 12.

Table 12: OIRFs of Gold Price; post-Brexit sample

Horizon	Impulse variable	Response Variable			
		Oil Price	**Gold Price**	**Exchange Rate**	**Growth Rate GDP**
0	Gold Price	0.000	24.932	-0.003	1.569
1	Gold Price	-0.120	6.076	-0.003	-0.540
2	Gold Price	0.743	0.923	0.0002	0.404
3	Gold Price	-0.066	0.622	-0.0003	-0.117
4	Gold Price	0.043	-0.055	0.0001	0.046
5	Gold Price	-0.018	0.042	-0.0000	-0.018
6	Gold Price	0.007	-0.013	0.0000	0.007
7	Gold Price	-0.003	0.006	-0.0000	-0.003
8	Gold Price	0.001	-0.002	0.0000	0.001

Note. The table provides the OIRFs when estimating the post-Brexit VAR model with one lag for gold price and the responses of oil price, gold price, exchange rate and the growth rate of nominal GDP. The impulse variable is shown in the second column and the horizon is provided in the first column.

The OIRFs of the exchange rate are shown in Table 13. When looking at the response of both the oil price and gold price, one can observe that both respond one period later than the occurrence of the shock. In both cases the response is negative in the first period after the shock. The response of the oil price becomes positive again in the next period, and starts fluctuating between a negative and positive response afterwards. When considering the plotted OIRFs in Figure 12, one can observe that the confidence interval moves in a similar way as the estimated response values. This suggests a reliable results when estimating the response of the oil price to a shock in the exchange rate. In case of the gold price, the response is also negative in the second period, but it becomes positive again in the third period. From the fourth period onwards, the values start shifting between negative and positive. However, the estimated confidence interval contains both positive and negative values. This makes it difficult to draw reliable conclusions based on these results. Lastly, the growth rate of nominal GDP responds positively to a shock in exchange rate directly, while it becomes negative again in the first period. Hereafter, the response becomes positive again in the second period. This shift between positive and negative values occurs until the shock eventually flattens out. This ripple effect is also shown when considering the plotted OIRF in Figure 12, where the confidence interval moves in the same way as the estimated values. This makes it possible to draw reliable conclusions on the response of the nominal GDP's growth rate to a shock in the exchange rate.

The OIRFs of the growth rate of nominal GDP are shown in Table 14. The results suggest that oil price, gold price and exchange rate all react in the first period after the shock. Both

Table 13: OIRFs of Exchange Rate; post-Brexit

Horizon	Impulse variable	Response Variable			
		Oil Price	**Gold Price**	**Exchange Rate**	**Growth Rate GDP**
0	Exchange Rate	0.000	0.000	0.008	0.464
1	Exchange Rate	-2.170	-2.290	-0.0004	-0.900
2	Exchange Rate	0.135	-1.333	0.0004	0.238
3	Exchange Rate	-0.042	0.171	-0.0002	-0.077
4	Exchange Rate	0.036	-0.058	0.0001	0.033
5	Exchange Rate	-0.015	0.024	-0.0000	-0.014
6	Exchange Rate	0.005	-0.012	0.0000	0.005
7	Exchange Rate	-0.002	0.004	-0.0000	-0.002
8	Exchange Rate	0.001	-0.002	0.0000	0.001

Note. The table provides the OIRFs when estimating the post-Brexit VAR model with one lag for exchange rate and the responses of oil price, gold price, exchange rate and the growth rate of nominal GDP. The impulse variable is shown in the second column and the horizon is provided in the first column.

oil price and gold price react positively to the shock in the growth rate of nominal GDP, while the exchange rate reacts negatively. The response of oil price increases again in the second period, only to become negative in the third period. Hereafter, the response of oil price becomes positive again and remains that way in both the fifth and sixth period. However, when considering the OIRF graph in Figure 12 of the response of oil price to a shock in exchange rate, the confidence interval includes both positive and negative values, making it an unreliable result to draw conclusions from. The response of the gold price also remains positive up to the third period. From the fourth period onwards the response values start shifting between positive and negative. The response of exchange rate starts shifting between a negative and positive value, starting from the first period up to the sixth period, after which the response dies out again. This ripple-effect is also portrayed when considering the plotted OIRF in Figure 12. As the confidence interval moves in a similar way as the estimated values, it is possible to draw a reliable conclusion from these results.

Here, a summary of the response of nominal GDP's growth rate to the gold price, exchange rate and oil price will be provided. When considering the response of the growth rate of nominal GDP to a shock in the gold price, the growth rate responds through a ripple effect, but reacts positively in the period of the shock and negatively in the first period after the shock. In case of the oil price, the growth rate reacts also positive in the period of the shock and negatively in the first two period after the shock. From the third period onwards, the values start shifting between small positive and negative values. In both cases, the confidence interval moves in a similar way as the estimated values, making it possible to draw reliable conclusions from these results. Lastly, GDP's growth rate reacts positively to a shock in the exchange rate in the period of the shock. From the first period of the shock, the response values start shifting

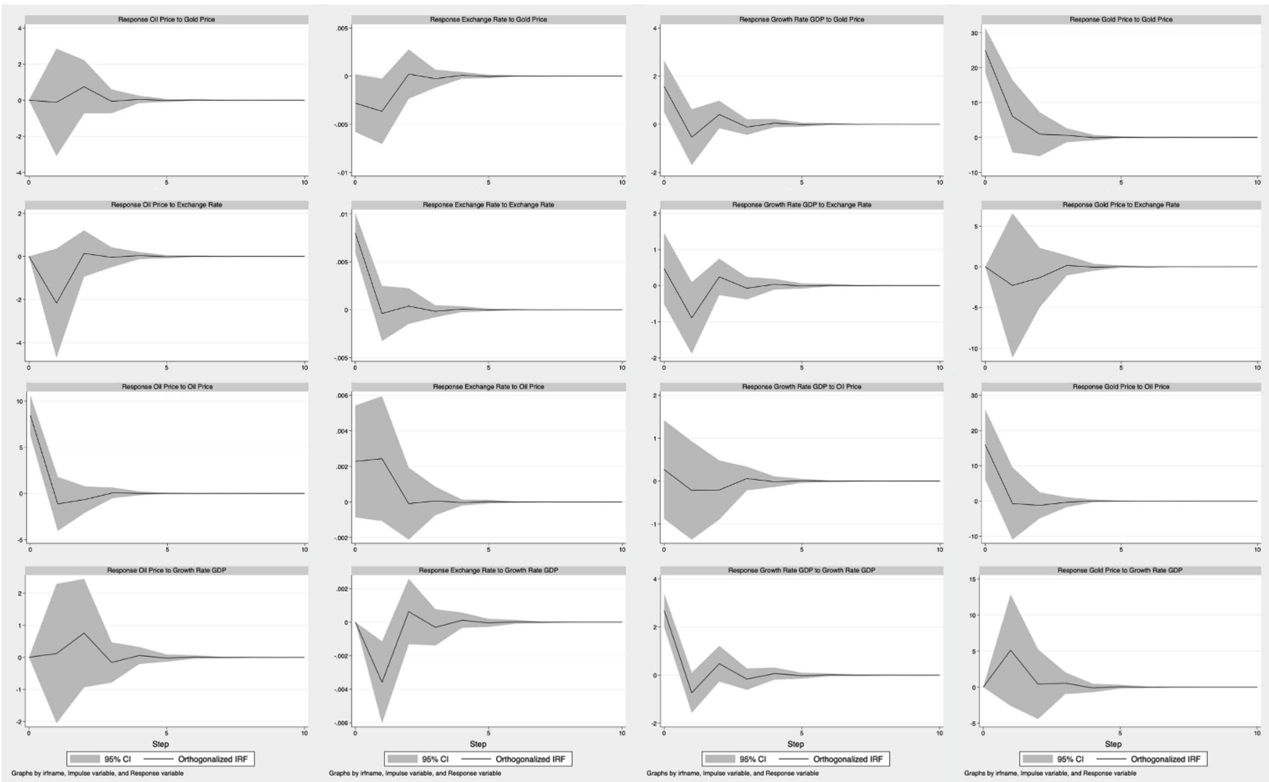
Table 14: OIRFs of growth rate of nominal GDP; post-Brexit

Horizon	Impulse variable	Response Variable			
		Oil Price	**Gold Price**	**Exchange Rate**	**Growth Rate GDP**
0	Growth Rate GDP	0.000	0.000	0.000	2.686
1	Growth Rate GDP	0.117	5.112	-0.003	-0.736
2	Growth Rate GDP	0.754	0.403	0.0006	0.474
3	Growth Rate GDP	-0.159	0.545	-0.0003	-0.168
4	Growth Rate GDP	0.055	-0.124	0.0001	-0.062
5	Growth Rate GDP	0.052	0.583	-0.00005	-0.024
6	Growth Rate GDP	0.010	-0.018	0.00002	0.010
7	Growth Rate GDP	-0.004	0.008	0.0000	-0.004
8	Growth Rate GDP	0.001	-0.003	0.0000	-0.014

Note. The table provides the OIRFs when estimating the post-Brexit VAR model with one lag for the growth rate of nominal GDP and the responses of oil price, gold price, exchange rate and the growth rate of nominal GDP. The impulse variable is shown in the second column and the horizon is provided in the first column.

between positive and negative, while gradually taking on smaller values. When considering the plotted OIRF, it is can be seen that the confidence interval moves in a similar way, ensuring the reliability of the results.

Figure 12: Plotted OIRFs; post-Brexit



Note. The figure represents the various impulse response functions in the post-Brexit sample. A VAR(1) model is estimated by using OLS over the sample January 1997 to March 2023. The 95% confidence interval is used.

When considering the pre- and post-Brexit responses of nominal GDP's growth rate to shocks in the gold price, oil price and exchange rate, it is interesting to note that some relations have changed in the post-Brexit sample compared to the pre-Brexit sample. In the case of the response of the nominal GDP's growth rate to shocks in oil price, these remained positive after the second period in the pre-Brexit sample, it now remains negative in the first and second period after shock, after which the response value starts fluctuating between a negative and positive value. However, there seem to be no other structural differences between the pre- and post-Brexit response of GDP's growth rate to a shock in the oil price.

When comparing the response of the growth rate of nominal GDP to a shock in the gold price, it can be concluded that a change in response did occur. The response of GDP's growth rate to a shock in the gold price was strictly negative pre-Brexit, while in the post-Brexit sample the so-called ripple effect occurs again. The growth rate of nominal GDP reacts positively to a shock in gold price in the period of the shock, negatively in the period after the shock and positively again in the second period after the shock. This impact converts back to zero after some time. Lastly, the response of the growth rate of nominal GDP to a shock in the exchange rate changed in the post-Brexit sample, compared to the pre-Brexit sample. In the pre-Brexit case, the growth rate of nominal GDP reacts strictly negative to a shock in the exchange rate, while in the post-Brexit case the initial reaction is positive and negative in the first period after the shock. The impact converges then back to zero after the fifth period. It thus seems that a structural change in the relationship between the exchange rate and the growth rate of nominal GDP has occurred in the post-Brexit sample.

5.4 Regression results

In this section, the results of the regression models as mentioned in section 3.5 will be discussed. There are two estimations per dependent variable; one where only the binary variable indicating whether Brexit occurred yet (basic model) and one where the explanatory and control variables for recessions, Covid-19 and the Ukraine-Russia conflict (full model) are included. The basic model is indicated by (1) and the full model is indicated by (2). Please note that all variables have either been log-transformed or standardised to correct for extreme outliers or differences in measurement. Additionally, all coefficients are provided with their robust standard errors in the parentheses below. The level of significance is indicated with $*, **$ or $* * *$, suggesting a 10%, 5% or 1% significance level respectively.

The regression results that examine the effect of Brexit on inflation are shown in Table 15 In both the basic and full model, Brexit has a significant effect. However, the effect in the basic model is positive and becomes negative in the full model. Adding the explanatory and control variables thus changes the associated Brexit effect. In the basic model, Brexit is associated with a significant increase of 1.4107 standard deviation units of inflation. In the full model, the associated effect significantly decreases inflation by -0.4794 standard deviation units. It can therefore be concluded that Brexit is (significantly) associated with a decrease in inflation. It is, however, important to note that the significance of the Brexit coefficient decreased in the full model.

Table 15: Regression results, Inflation

	ΩInflation	
	(1)	(2)
Brexit	1.4107***	−0.4784*
	(0.3408)	(0.2547)
ΩReal GDP growth		−0.011
		(0.0184)
Log(Import)		1.011**
		(0.4854)
Log(Government Spending)		−0.5611
		(0.6034)
ΩM3 growth		0.092
		(0.0612)
ΩWage growth		0.042
		(0.0475)
Log(Interest rate)		−0.2872***
		(0.0921)
Log(Exchange rate)		−3.1431***
		(0.4095)
Recession		0.5842***
		(0.0925)
War		3.1221***
		(0.5887)
ΩPositive cases		0.1807***
		(0.0451)
Constant	−0.1702***	−6.2192**
	(0.034)	(2.6888)
N	315	255

Note. The table shows the regression results for the standardised inflation. Two regression models are estimated, one basic model (indicated by (1)) and one full model (indicated by (2)). The robust standard errors per coefficient are shown in the parentheses below said coefficient. The coefficients are given with their respective significance level, with the following p-values: $p^{*} < 0.1$, $p^{**} < 0.05$ and $p^{***} < 0.01$.

Table 16: Regression results, Household consumption

	Log(Household Consumption)	
	(1)	(2)
Brexit	0.1299***	−0.1525***
	(0.0149)	(0.0212)
ΩInflation		0.0113***
		(0.0032)
Log(Household Income)		0.3435***
		(0.0508)
Log(Government Spending)		0.131***
		(0.0372)
Log(Interest Rate)		0.0056*
		(0.0032)
Log(Unemployment Rate)		−0.01396***
		(0.0124)
Recession		0.0132***
		(0.0047)
War		−0.0059
		(0.0160)
ΩPositive cases		0.0062
		(0.0038)
Constant	12.5473***	7.1137***
	(0.0080)	(0.2945)
N	315	302

Note. The table shows the regression results for the household consumption. Two regression models are estimated, one basic model (indicated by (1)) and one full model (indicated by (2)). The robust standard errors per coefficient are shown in the parentheses below said coefficient. The coefficients are given with their respective significance level, with the following p-values: $p^{*} < 0.1$, $p^{**} < 0.05$ and $p^{***} < 0.01$.

The regression results that estimate the effect of Brexit on household consumption, as mentioned in equation 6, are shown in Table 16. The coefficient of Brexit is significant in both models. However, in the basic model, Brexit is associated with a significant increase of 12.99% in household consumption. In the full model, the value of the Brexit coefficient changed to −0.1525, while still being significant for $\alpha = 0.01$. In the full model Brexit is thus associated with a significant decrease of 15.25% in household consumption. In the full model inflation, household income, government spending, unemployment rate and recession all have a highly significant impact on household consumption. Interest rate has a significant coefficient as well, however it is only significant at the 10% level, instead of 1%. Based on these results, it is concluded that Brexit is associated with a significant decrease of 15.25% in household consumption.

The results of estimating the effect of real GDP growth on Brexit (see equation 7), are shown in Table 17. Here, two models are estimated as well. In both the basic and full model, Brexit is not associated with a significant change in the standardised real GDP growth. In the full model, only recession seems to have a highly significant impact on the real GDP growth. There is thus no reason to assume that Brexit had a significant impact on the real GDP growth. The regression results that estimate the effect of Brexit on government spending are shown in Table 18. The regression equation that is used here is defined in equation 8. In this case, the coefficient of Brexit is highly significant (at the 1% level) in both models. In the basic model, Brexit is associated with a significant increase of 58.75% in government spending. In the full model Brexit is associated with a significant increase of 11.43% in government spending. By adding additional explanatory and control variables, the estimated effect thus decreased. In the full model, all added explanatory variables are significant at the 5% or 1% level. Based on these results it can thus be concluded that Brexit significantly increased government spending by 11.43%.

The regression results that estimate the effect of Brexit on the UK's balance of trade are shown in Table 19. The corresponding regression equation is provided by equation 9. In the basic model, the Brexit coefficient is not significant. However, in the full model, the Brexit coefficient is significant at the 1% level. This indicates that the added explanatory variables have contributed to explaining the effect of Brexit on the UK's balance of trade. As the balance of trade has been standardised, Brexit is associated with a significant increase of 1.6597 in standard deviation units of the balance of trade. This indicates that Brexit has had a significant positive effect on the balance of trade of the UK. The estimation results that show the effect of Brexit on the unemployment rate are given in Table 20. Here the coefficient of Brexit is significantly negative in both the basic and full model. In the basic model, Brexit is associated with a significant decrease of 30.06% of the unemployment rate. This effect more than doubled in the full model, indicating that Brexit has significantly decreased the unemployment rate by 60.14%. Additionally, almost all added explanatory variables are significant at the 1% level, except for the standardised number of positive Covid-19 cases. These results suggest that Brexit has significantly decreased the unemployment rate.

When estimating the regression equations, all were tested for multicollinearity by calculating the variance inflation factors (VIFs). When examining the values of the various VIFs, there were no signs of severe collinearity in the models. Additionally, all models were tested for heteroscedasticity, of which no signs were found.

In summary, Brexit is associated with a significant decrease in inflation and household consumption, an increase in government spending and the effect on real GDP growth remains unclear. Additionally, Brexit is associated with a significant positive effect on the UK's balance of trade and a significant negative effect on the unemployment rate (which thus decreased). These regression results suggest an overall positive economic effect of Brexit on the UK's econ-

Table 17: Regression results, Real GDP growth

	ΩReal GDP growth (1)	(2)
Brexit	0.2753	0.5908
	(0.4556)	(0.990)
ΩInflation		−0.0628
		(0.0857)
ΩYield curve		−0.2182
		(0.1380)
Log(Interest Rate)		0.1340*
		(0.0747)
Log(Unemployment Rate)		0.5489*
		(0.2910)
Recession		−0.4244***
		(0.1346)
War		−0.4044
		(0.3912)
ΩPositive Cases		−0.0577
		(0.1538)
Constant	−0.0332**	−0.9868*
	(0.0135)	(0.5613)
N	315	305

Note. The table shows the regression results for the standardised real GDP growth. Two regression models are estimated, one basic model (indicated by (1)) and one full model (indicated by (2)). The robust standard errors per coefficient are shown in the parentheses below said coefficient. The coefficients are given with their respective significance level, with the following p-values: $p^{*} < 0.1$, $p^{**} < 0.05$ and $p^{***} < 0.01$.

Table 18: Regression results, Government Spending

	Log(Government Spending) (1)	(2)
Brexit	0.5875***	0.1143***
	(0.0234)	(0.0278)
ΩReal GDP growth		−0.0132**
		(0.0066)
ΩCurrent Account		−0.016**
		(0.0076)
Log(Interest Rate)		−0.1379***
		(0.0181)
Log(Government Debt)		0.2765***
		(0.0256)
Log(Unemployment Rate)		−0.3219***
		(0.0371)
Log(Exchange Rate)		−0.9723***
		(0.0711)
Recession		0.0692***
		(0.0118)
War		−0.1064**
		(0.0473)
ΩPositive Cases		−0.0150**
		(0.0065)
Constant	10.826***	9.1464***
	(0.0187)	(0.1989)
N	312	302

Note. The table shows the regression results for the log-transformed government spending. Two regression models are estimated, one basic model (indicated by (1)) and one full model (indicated by (2)). The robust standard errors per coefficient are shown in the parentheses below said coefficient. The coefficients are given with their respective significance level, with the following p-values: $p^{*} < 0.1$, $p^{**} < 0.05$ and $p^{***} < 0.01$.

omy, which is not in line with the predictions made in regards to the potential effects of a hard Brexit. Even though the effect of Covid-19 was included through the number of positive cases, the effect of Covid-19 is more than just a shock. It thoroughly changed people's lives through lock-downs and social distancing measures. Additionally the government implemented several policies to keep companies running and employees from losing their jobs. By doing so, the unemployment rate dropped. This can cause a bias in the estimated effect of Brexit on the unemployment rate. Additionally, the extreme support by the government during this pandemic, can also cause an upward bias in the estimated result of the Brexit effect on government spending.

When considering inflation, it has significantly increased during the Ukraine-Russia conflict, most likely driven by the increased oil and gas prices. The measured increase in inflation can thus partially be attributed towards this conflict, and partly to Brexit. In the case of inflation, it is important to remember that it is measured based on a comparison to 12 months prior.

Table 19: Regression results, Balance of Trade

	ΩBalance of Trade	
	(1)	**(2)**
Brexit	−0.4561	1.6597***
	(0.3474)	(0.3535)
ΩReal GDP growth		−0.187**
		(0.0816)
ΩInflation		0.2704***
		(0.1041)
Log(Exchange Rate)		1.4949***
		(0.3091)
ΩTrade proxy		−0.4432***
		(0.0829)
Recession		0.0166
		(0.1003)
War		−3.9521***
		(0.6209)
ΩPositive Cases		−0.5183***
		(0.1229)
Constant	0.055	2.3647***
	(0.0423)	(0.4140)
N	315	305

Note. The table shows the regression results for the standardised balance of trade. Two regression models are estimated, one basic model (indicated by (1)) and one full model (indicated by (2)). The robust standard errors per coefficient are shown in the parentheses below said coefficient. The coefficients are given with their respective significance level, with the following p-values: $p^{*} < 0.1$, $p^{**} < 0.05$ and $p^{***} < 0.01$.

Table 20: Regression results, Unemployment Rate

	Log(Unemployment Rate)	
	(1)	**(2)**
Brexit	−0.3006***	−0.6014***
	(0.0240)	(0.0907)
ΩReal GDP growth		0.0540***
		(0.0180)
ΩInflation		0.0909***
		(0.0140)
Log(Government Spending)		1.1104***
		(0.1171)
Log(Household Consumption)		−3.0509***
		(0.2638)
Recession		−0.0412***
		(0.0151)
War		−0.1861***
		(0.0703)
ΩPositive Cases		0.0047
		(0.0139)
Constant	1.7372***	0.5777***
	(0.0130)	(0.1637)
N	314	302

Note. The table shows the regression results for the log-transformed unemployment rate. Two regression models are estimated, one basic model (indicated by (1)) and one full model (indicated by (2)). The robust standard errors per coefficient are shown in the parentheses below said coefficient. The coefficients are given with their respective significance level, with the following p-values: $p^{*} < 0.1$, $p^{**} < 0.05$ and $p^{***} < 0.01$.

This can cause a measurement issue, as the prices are compared to (relatively) very low prices of the previous year. Especially when measuring the effect of Brexit, this may cause issues due to the close timing of Brexit and the pandemic.

6 Conclusion

The primary objective of this study was to analyse the short-term macroeconomic effects of Brexit on the UK's economy. To present comprehensive findings, here a summary of the research will be provided, from which conclusions will be drawn, followed by an examination of the research's limitations.

Prior studies mostly relied on predictions, forecasting and general equilibrium models to estimate and assess the costs and consequences of Brexit. However, all of these studies encountered a challenge due to uncertainty of the potential trade agreements that would be established between the UK, the EU and other economies. In contrast, the present study does have this information, as the trade agreement is now known and thus eliminates this aspect of uncertainty. Most of these prior studies handled this uncertainty by focusing on various scenarios, that of a soft Brexit and that of a hard Brexit. In the case of a soft Brexit, most researchers found the consequences and costs of Brexit to be relatively small. When considering a hard Brexit, the overall consensus was that the costs and consequences would be more severe.

The trade agreement that has been established lies closer to a hard Brexit. It was thus expected that the consequences of Brexit on the UK's economy would be quite severe. This was assessed by using various econometric methods. Firstly, a VAR was used to determine whether there have been structural changes in the relationship between economic growth and deterministic macroeconomic variables, namely oil price, gold price and exchange rate. As Brexit occurred almost simultaneously with the Covid-19 pandemic, the issue of adjusting for the extreme outliers caused by it rose. This was eventually done by using the method proposed by Ng (2021). Additionally, other macroeconomic variables where examined in order to determine the effect that Brexit had on them. These variables include inflation, household consumption, real GDP growth, government spending, balance of trade and the unemployment rate. The Brexit effect on these variables was examined by using a regression model, which included an interaction term to address the issue of potential mutlicollinearity. Additionally, independent control variables were added to incorporate recessions, the Ukraine-Russia conflict and the Covid-19 pandemic.

The results of the VAR model suggest no structural changes in the response of the growth rate of nominal GDP to a shock in gold price and oil price. However, the response of GDP's growth rate to a shock in exchange rate did happen when comparing the pre- and post-Brexit sample. In the pre-Brexit sample, GDP's growth rate reacted negatively to a shock in exchange rate for the whole period. However, after Brexit, the growth rate of nominal GDP reacted positively to a shock in the exchange rate in the period of the shock. Hereafter the response value starts shifting between a small positive and negative value.

In case of the regression results, it estimates that Brexit significantly decreased inflation by 0.4784 standard deviation units, significantly decreased household consumption by 15.25%, significantly increased government spending by 11.43%, significantly increased the balance of trade by 1.6597 standard deviation units, the unemployment rate decreased significantly by 60.14% and the effect on real GDP growth remains unclear. These results suggest an overall positive effect of Brexit on the UK's economy. This is not in line with the predictions discussed previously. The potential bias in the results can be caused by the Covid-19 pandemic. In these models the pandemic is incorporated through the number of positive cases and modelled as an exogenous shock. However, the pandemic changed lives drastically through lock-downs and other social distancing measures. This is something that is potentially not incorporated thoroughly enough into the regression model and can cause large biases in the results. Furthermore, there is always the issue of omitted variable bias.

Overall, the results show mixed effects of Brexit. On the one hand, the regression results show a positive effect, but it remains difficult to determine whether this is also the pure Brexit effect. However, dealing with Covid-19 biases in data is something that more studies will presumably have to overcome. The VAR results only suggest a change in responses to national GDP growth when the exchange rate is taken into account.

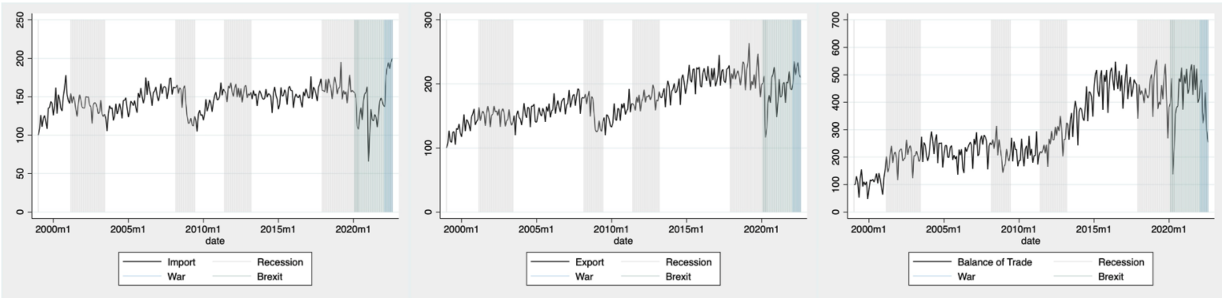
The topic of Brexit is one that will need more research in the future. As time passes, the post-Brexit sample will become larger as more observations will be added. This will make it possible to use other estimation methods that require larger sample sizes. It could also be possible to first construct a theoretical model that can measure the effects of Brexit. This can then be used to predict the effect of Brexit, which can then be compared to the actual values and filter out the Covid-19 effect by doing so. Dealing with Covid-19-biases will in time, hopefully, become easier as well. As more research is likely to encounter this issue, more advanced methods will be developed to de-Covid the data.

Further research could, for example, focus on applying a Regression Discontinuity Design (RDD) to try and estimate the effect of Brexit on macroeconomic variables and determine whether these are very different from the effects found here. Additionally, a structural VAR or Vector Error Correction Model (VECM) can be applied to address the relatively small sample size of the post-Brexit sample.

Appendix A

The trade patterns between the EU and UK are shown in Figure 13. The trade patterns between the UK and Germany are provided in Figure 14. In the third Figure (Figure 15), the trade patterns between the UK and France are shown. Lastly, in Figure 16, the trade patterns between the UK and the Netherlands are displayed. One can observe a large drop in the balance

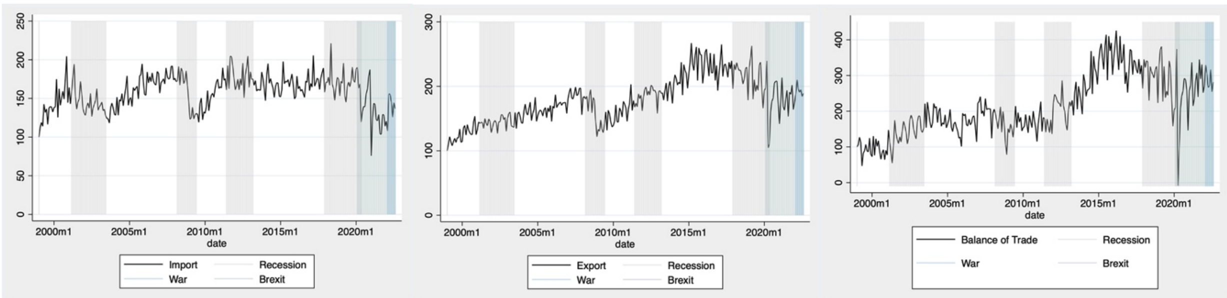
Figure 13: Trade patterns between the EU and UK



Note. The figure shows the development of the indexed trade patterns between the EU and the UK. The left figure displays the import by the EU from the UK, the middle figure shows the exports from the EU to the UK and the most right figure shows the balance of trade of the EU and its trade with the UK. The base-year for the index is 1999m1

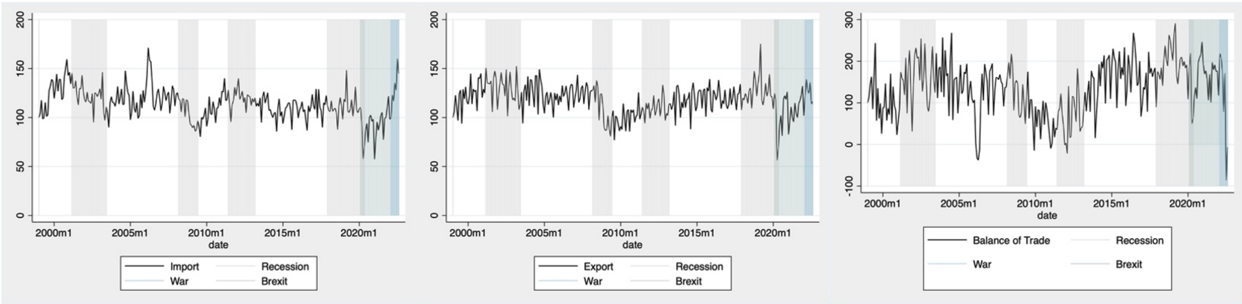
of trade in the case of trade between the EU and UK, Germany and the UK, France and the UK and the Netherlands and the UK around the same time as Brexit and Covid-19. Furthermore, a shift in pattern is observed in the case of the trade between the UK and the Netherlands after this period. The balance of trade seems to have decreased drastically. A similar observation can be made for France.

Figure 14: Trade patterns between the UK and Germany



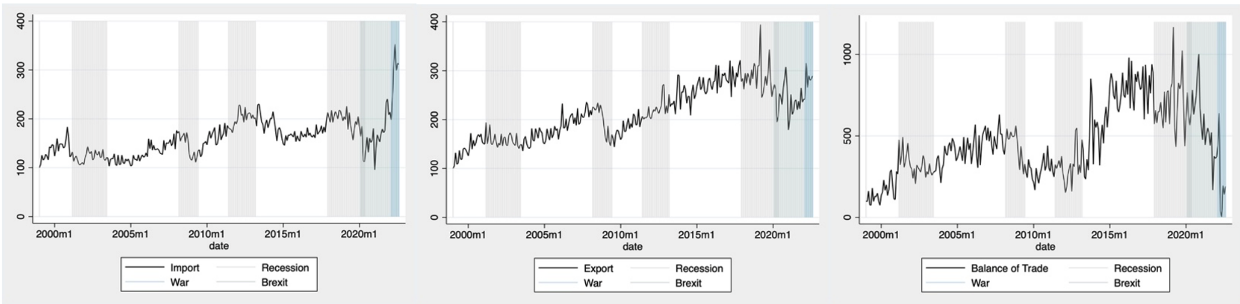
Note. The figure shows the development of the indexed trade patterns between the UK and Germany. The left figure displays the import by the UK from Germany, the middle figure shows the exports from the UK to Germany and the last figure shows the balance of trade of the UK with its trade with Germany. The base-year for the index is 1999m1

Figure 15: Trade patterns between the UK and France



Note. The figure shows the development of the indexed trade patterns between the UK and France. The left figure displays the import by the UK from France, the middle figure shows the exports from the UK to France and the last figure shows the balance of trade of the UK with its trade with France. The base-year for the index is 1999m1

Figure 16: Trade patterns between the UK and the Netherlands

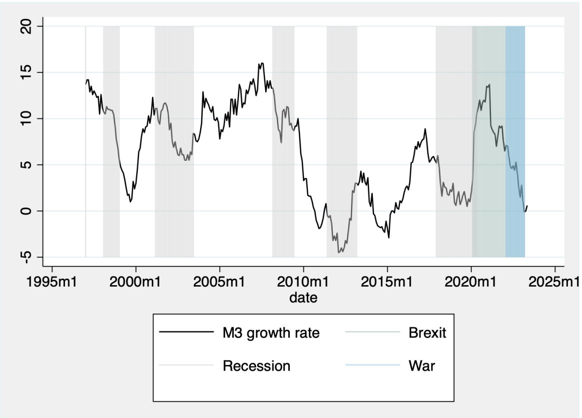


Note. The figure shows the development of the indexed trade patterns between the UK and the Netherlands. The left figure displays the import by the UK from the Netherlands, the middle figure shows the exports from the UK to the Netherlands and the last figure shows the balance of trade of the UK with its trade with the Netherlands. The base-year for the index is 1999m1

Appendix B

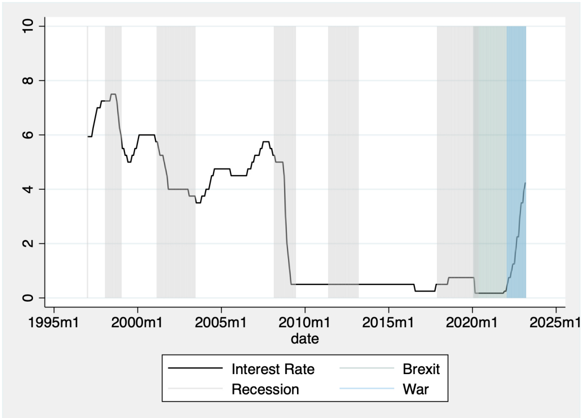
Here, the graphical representation of various explanatory variables will be discussed. Figure 17 shows the development of M3 money growth over time. The money growth rate seems to fluctuate and when considering recessions, a decline is observed in the growth rate simultaneously. furthermore in February 2020, a large increase in M3 money growth is observed. This, however, decreases again over time. Figure 18 portrays the development of the interest rate over time. The interest rate decreased gradually over time, and almost reached its zero lower bound. After December 2021, the interest rate starts increasing again after being very close to its zero lower bound.

Figure 17: M3 money growth



Note. The graph portrays the development of M3 money growth over time. The data observations start in January 1997 and end in May 2023. M3 growth rate decreases often in case of recessions. From February 2020, a large increase in M3 money growth occurred, which decreased again.

Figure 18: Interest Rate

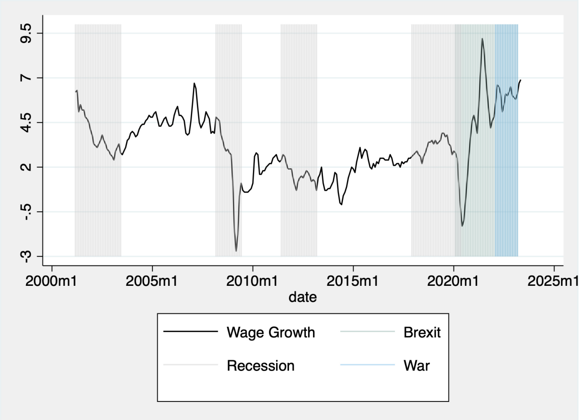


Note. The graph portrays the development of the interest rate over time. The data observations start in January 1997 and end in March 2023. The interest rate has decreased since February 2009, almost reaching its zero lower bound. It started increasing again in February 2020.

Figure 19 portrays the development of wage growth over time. The wage growth seems to fluctuate and has known two very extinctive drops. One of these decreases occurred in May 2020. However, the wage growth recovered relatively fast and reached its maximum value in June 2021. After June 2021 the wage growth decreases again, but remains higher than before. Figure 20 shows the development of household income over time. Household income seems to have an upward trend over time and fluctuates in a similar pattern. It has reached it all time high in October 2022.

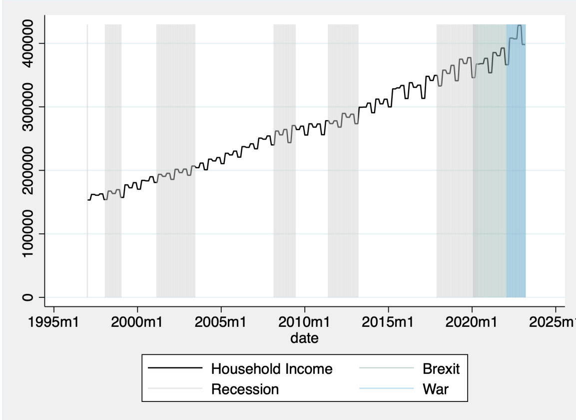
The development of the yield curve is shown in Figure 21. The yield curve shows the relationship between the short-term and long-term interest rate on a government bond with a maturity of 60 months (or 5 years) in this case. Until July 2020, the yield has a downward trend. After July 2020 the yield starts increasing again until October 2022. Figure 22 shows the path of government debt over time. The government debt has an upward trend and experiences a sharp increase in June 2020. This large increase could very well be related to Covid-19. The

Figure 19: Wage growth



Note. The graph shows the trajectory of wage growth over time. The data observations start in March 2001 and end in May 2023. The wage growth seems to fluctuate over time and has two relatively large drops, one of these occurs in May 2020. However, the wage growth recovers again and reaches its maximum value in June 2021.

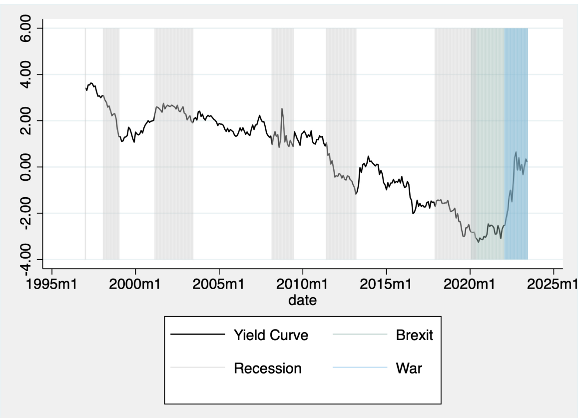
Figure 20: Household Income



Note. The graph shows the trajectory of household income over time. The data observations start in January 1997 and end in March 2023. The household income has an upward trend, but fluctuates over time. A similar patterns seems to repeat itself. Household income reaches its maximum value in October 2022.

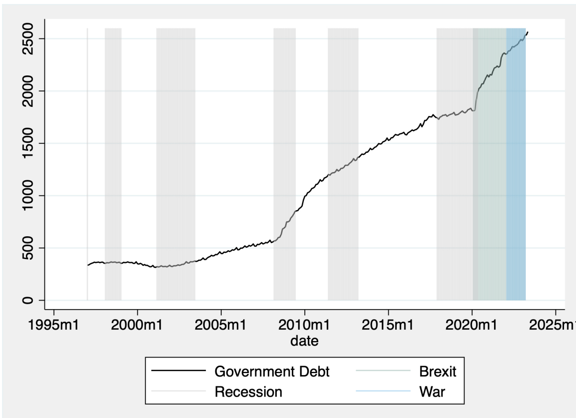
observations for government debt start in January 1997 and end in May 2023. The development of the current account over time is shown in Figure 23. From this graph, it can be deducted that the current account fluctuates quite often during the time period of January 1997 and March 2023. The current account experiences a large peak in October 2019, which is followed by a very large drop in October 2020. The lowest value of the current account is reached in January 2022. However, the current account did recover from this large drop. Lastly, please note that the current account is mostly negative and only has a positive value in a limited periods.

Figure 21: Yield curve



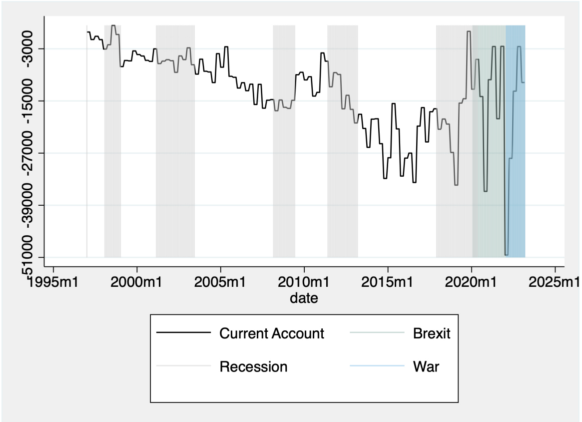
Note. The graph shows the trajectory of the yield curve over time. The data observations start in January 1997 and ends in June 2023. The yield curve has been decreasing over time, but experienced a sharp increase in July 2020. It started decreasing again after October 2022.

Figure 22: Government Debt



Note. The graph portrays the path of government debt over time. The data observations start in January 1997 and ends in May 2023. Government debt has an upward trend, but experiences a sharp increase in June 2020, which may be related to Covid-19.

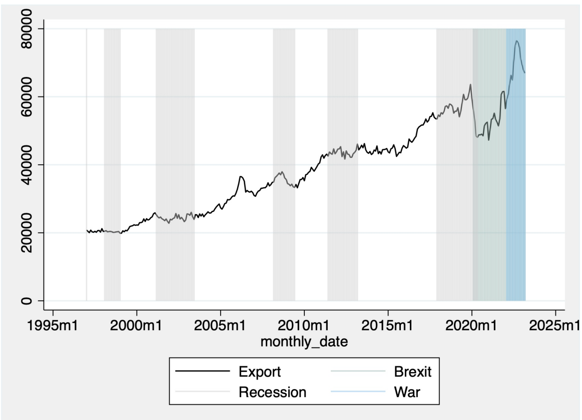
Figure 23: Current Account



Note. The graph shows the trajectory of the current account over time. The observations start in January 1997 and ends in March 2023. The current account fluctuates a lot and is mostly negative. The lowest value of the current account is observed in October 2022.

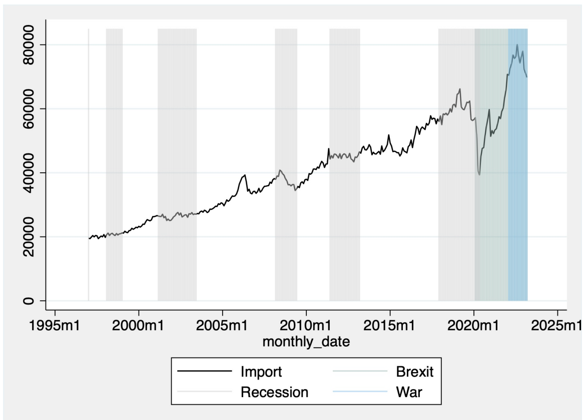
Next, Figure 24 shows the trajectory of exports over time. Here, the data starts in January 1997 and ends in March 2023 as well. A decrease in exports occurs in January 2020. However, exports recover and increase again until a decrease in September 2022. Figure 25 portrays the development of import over time. The observations start in January 1997 and end in March 2023. In the graph, one can see a short-lived but sharp decline in April 2020 after which imports increase again. After August 2022, another decline seems to occur.

Figure 24: Export



Note. The graph portrays the development of export over time. The data observations start in January 1997 and end in March 2023. Exports decrease after January 2020 and increase until September 2022. After September 2022, another drop occurs.

Figure 25: Import



Note. The graph portrays the development of import over time. The data observations start in January 1997 and end in March 2023. A relatively sharp decrease occurs in April 2020, after which import increases again. However, imports decrease again after August 2022.

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