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What factors affected the voting pattern in the Brexit referendum?

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Abstract

Though the Treasury stated that leaving the EU would lead to high economic costs for the UK, people still voted to leave. Since the referendum was held, many researchers have tried to explain what factors influenced the outcome of the vote. The aim of this dissertation is to further contribute to the existing research.

This will be done by analysing variables based on demographic, as well as economic factors, through cross-sectional data from the 133 NUTS 3 regions in England. They will be used in a bivariate analysis and a multivariate analysis as well as a multivariate analysis with robust standard errors in relation to the dependent variable share of votes in favour of leaving.

The results of the analysis showed significant results for age, people working in the exporting industry and GDHI. When the regression was run without robust standard errors, voting turnout was also found to be a significant variable.

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1. Introduction

As a result of the referendum held on the 23rd of June 2016, The United Kingdom decided to leave the European Union, hereinafter abbreviated as UK and EU. The withdrawal from the EU has come to be called “Brexit”, a portmanteau of the two words “Britain" and “exit”. In January of 2020, the Withdrawal Agreement was signed and the terms of separation of the UK from the EU were settled (Baldwin & Wyplosz, 2021). The UK and EU, post-referendum, have undergone months of negotiations regarding their future relationship. The negotiations resulted in, among other things, The Trade and Cooperation Agreement (European Commission, n.d.). During the campaign, The Treasury published a research report stating that leaving the EU would result in a 6 percent smaller economy by 2030, as well as an average household cost of £4 300 (BBC, 2016a). With a potential economic cost this size, what may have influenced people to vote for Brexit?

Since the EU referendum, many researchers have tried to identify what factors influenced the outcome of the vote. In their research, Goodwin and Heath (2016) found that the result in the referendum was not only about the relationship between the UK and the EU, but rather about the internal existing conflicts. For instance, multiple researchers found that factors such as household income influenced the results, with higher income households being more in favour of remaining while lower income households to a larger extent voting in favour of leaving. Researchers Becker, Fetzer and Novoy (2017) concluded that it is not possible to give a causal explanation to the result of the referendum since there are many factors influencing the results. However, it is possible to look for variables that covariate with the results.

The purpose of this dissertation is to contribute with additional conclusions, as well as questioning the results of previous research, regarding what factors affected the outcome of the 2016 EU referendum. This dissertation contributes with new insights to the field by introducing a new variable as well as creating variables based on previous research but with a different approach. The aim is to see what new conclusions can be drawn, as well as to find to what extent the results of this dissertation align with the previous research findings.

The results of the analysis support previous research findings, that those with a lower age and those with a higher GDHI were less likely to support Brexit. A positive statistically significant relationship was also found between people working in the top exporting industry and leave share which the writers suggested could be explained by correlation with an omitted variable. When the multivariate regression was run without robust standard errors, a relationship was also found indicating that an increase in voter turnout covariated with more votes in favour of Brexit.

The dissertation starts with the *Background,* that covers the history regarding the referendum and the campaigns for the leave and remain side. This will be followed by the section *Previous research*. In section four, *Empirical theory* will be presented, where information on the data used in the research will be presented as well as limitations and expectations. This will then be followed by the *Empirical selection*, which consists of an econometric discussion. After that the section, *Empirical results* follows, where the bivariate analysis and multivariate analysis are performed using the econometric tool GRETL. The section will end with a multivariate analysis with robust standard errors to account for problems caused by omitted variables. Furthermore, the result will be used in a discussion in the section *Discussion on the results*, this will be done through hypotheses based on previous research on the topic as well as economic theory. The dissertation will then end with the *Conclusion*.

2. Background

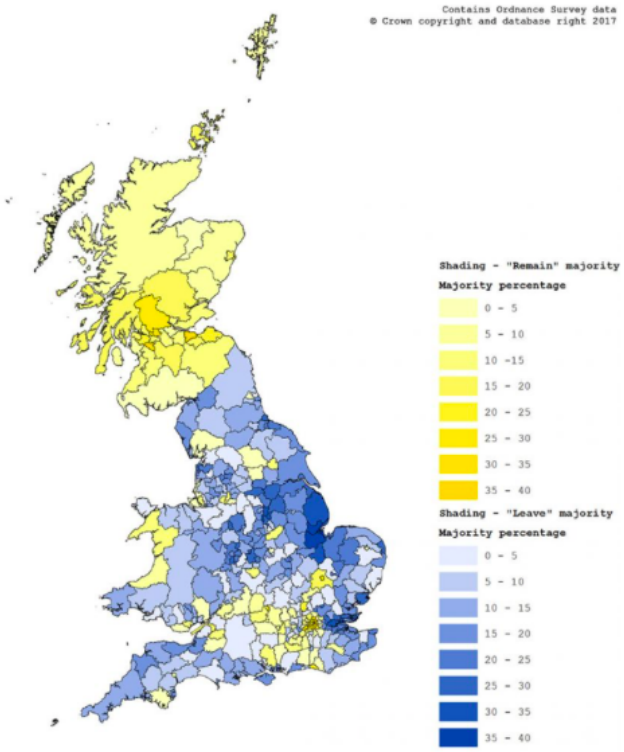
2.1 Background on Brexit

In 1975, the people in the UK voted on whether or not to stay in the European Community with an overwhelming majority voting to stay (UK Parliament, n.d.). Since then, multiple campaigns to withdraw first from the European Community and later on the EU followed. However, no referendum was ever held as it was always blocked by the Parliament, House of Commons or the House of Lords (BBC, 2015).

That was until 2015 when a new law, The European Union Referendum Bill, was put into place which required a referendum to be held. David Cameron, Prime Minister at the time and leader

of the conservative party, had made a promise to renegotiate Britain's EU membership and that the British people would then be given the chance to vote on whether they should stay with this new deal. During the end of 2015 and beginning of 2016, the new deal was made. Though the Prime minister himself seemed satisfied with the outcome, others found he had not gotten what he had promised. On the 20th of February 2016, it was announced that the referendum would be held on the 23rd of June that same year. The campaign went on until the vote with a spending budget of £7 million using public funding (BBC, 2016b).

The vote ended with 51.9 percent leave and 48.1 percent remain (BBC, n.d.). As the UK voted to leave the EU, Cameron resigned and was replaced by the Conservative party member Theresa May. On the 29th of March 2017, May invoked Article 50 of the Lisbon Treaty, the legal procedure for a member country to leave the EU. In November the following year, the EU and the UK agreed on a withdrawal agreement finalising the terms under which they would exit (Hayes, 2021).



Source: Oxford University (2017)

2.2 Leading up to Brexit

The campaigns leading up to the referendum had, to some degree, opposing arguments. The remain campaign argued that leaving the EU would, in the best case, result in economic insecurity, whilst in the worst case it could lead to a crash in the economy. The leave-side argued that, by leaving the EU, the UK would "take back control" over immigration as well as legislation and the UK's incomes and expenses (Myndigheten för ungdoms- och civilsamhällesfrågor, n.d.).

A survey done by IPSOS Mori 2014, discussing current issues in the UK, found that 50 percent of the participants perceived immigration as one of the most critical issues the UK was facing. Along with that, economy and unemployment accounted for 27 percent and 17 percent respectively of the issues in the UK according to the participants (Brinded, 2015).

Furthermore, the perceived issue of immigration may have intensified in 2015 when the EU experienced the biggest refugee crisis since the second world war. Through its geographical location as well as not being part of the Schengen area, the UK was able to keep more autonomy over its borders than other EU countries. Still, it had one of the most vocal oppositions against asylum seekers in the EU. In reality, since the UK was already not a part of the EU's common asylum policies, leaving the EU would have little effect on the UK's responsibility during the refugee crisis. Nevertheless, with the power of language, using the term immigrant, even when referring to refugees, the leave campaign was able to form an anti-immigration campaign and conceal the legal difference between EU citizens moving freely within the EU and asylum seeking refugees (Garrett, 2019).

Furthermore, Brexit supporters claimed that the UK was sending 350 million pounds to the EU, and expressed a desire to give that money to the National Health Service instead. The 350 million pounds was an estimation of the total EU fee, not accounting for the EU-funding that the UK received as well as the discount on the membership fee that the UK had had since the middle of the 1980s (Payne, 2016).

However, the EU-commission had predicted that the new inner market, with hundreds of legislations, would lead to between 4.25 and 6.5 percent extra increase in economic growth since 1992 while in fact, the World Bank published numbers showing that the yearly economic growth was much less than this (Myndigheten för ungdoms- och civilsamhällesfrågor, n.d.). Furthermore, the leave campaign said that they believed that they could get better deals with the rest of the world worth more than the economic benefits of trading with the EU but also that they would have the upper hand when negotiating with the EU. This is due to the trade balance where the UK imported more from the EU than it exported (Wintour, 2016).

In the years leading up to announcing the Brexit referendum, nearly one third of the population in the UK had at one point experienced relative income poverty for reasons such as unemployment (Pike, MacKinnon, Coombes, Champion, Bradley, Cumbers, Robson & Wymer, 2016). By targeting lower-income and working-class groups, with messages such as that relating to immigration and to the funds being sent to the EU, they could gain votes out of dissatisfaction by suggesting that these people would be better off if the UK was no longer a part of the EU (Behr, 2016).

3. Previous research

In light of the EU referendum in 2016, many have tried to explain what prompted people to vote the way that they did. According to multiple sources the main driving force for voting leave was immigration. An overwhelming majority disapproved of how the EU handled the refugee crisis in 2015 (Garrett, 2019). Harding (n.d.) concludes that how people viewed immigration had a major impact on how they voted. This separates Harding's research as he found that it is not only how important people found immigration to be as a political topic, but whether people believe it to be an issue or an economic gain. Those who saw immigration as a problem were more likely to vote in favour of Brexit while those who believed that immigration was good for the economy were more likely to vote in favour of remaining in the EU. In 2004, eight eastern european countries joined the EU which was followed by mass labour migration to countries such as the UK. This led to an increase in anti-european sentiment in the areas that received most of the labour migrants (Becker & Fetzer, 2017).

Migration was not the only factor that seemed to have influenced people's vote in the referendum. Individual characteristics such as age were suggested by Baldwin and Wypkosz (2021) to have played a role in the voting pattern. An overwhelming majority of 18-24 year olds voted in favour of remaining in the EU while a majority of those over 65 voted in favour of leaving. The mid 40s appeared to be a point where the votes shifted. This meant that those who were younger than their mid 40s, to a larger extent voted in favour of remaining in the EU, whilst those older were more likely to support Britain's exit from the EU (Finlay, Nayak, Benwell, Hopkins, Pande & Richardson, 2020).

Baldwin and Wypkosz (2021) also wrote that a majority of those with jobs voted in favour of remaining while a majority of those without jobs or retired voted in favour of leaving. These results were supported by the research published by Goodwin and Heath (2016), where they state that 59 percent of the unemployed voted to leave the EU while only 45 percent of those with full employment voted to leave.

Furthermore, Goodwin and Heath (2016) found that 58 percent of households with an income of less than £20 000 per year voted in favour of Brexit while only 35 percent of households with an income over £60 000 per year did the same. Similarly, after analysing 382 voting areas, Burn-Murdoch presented graphs that illustrated the correlation between areas with a high number of degree-educated inhabitants and fewer votes in favour of leaving (Financial Times, 2016). However, Goodwin and Heath (2016) found that not only the struggling or low skilled workers themselves supported Brexit but also those with higher education that lived in worse off areas tended to support Brexit as well. Additionally, the areas with a majority of leave votes had experienced a lower level of economic growth in relation to other regions (Fetzer & Wang, 2020).

Lastly, British election researchers have studied the subject of election participation. In the EU referendum 72.2 percent participated, this compared to the 2015 primary election where only 66.4 percent participated. They came to the conclusion that the unusually high voting turnout in the EU referendum was to the advantage of the leave-side (Myndigheten för ungdoms- och

civilsamhällesfrågor, n.d.). Reaching the same conclusion was Leslie and Ari (2018), who also found that the areas with a higher voting turnout were more likely to support Brexit.

4. Empirical theory

The purpose of this dissertation is to find what factors may have influenced the voting pattern in the EU referendum in England. While previous research to a large extent analysed individual data, such as examining what percentage of unemployed voted in favour of leaving the EU, this dissertation takes a different approach. This research is based on cross-sectional data of the NUTS 3 regions, in England. NUTS, short for Nomenclature of territorial units for statistics, divides the EU and the UK into economic territory for statistical purposes, 3 means it is the smallest division of territory for this system (Eurostat, n.d.). England is divided into 133 regions consisting of counties and unitary authorities (Office for National Statistics, n.d.). This dissertation intends to delve into the covariance of the results of the vote with economic factors of the regions as well as other variables that were likely to influence the vote as to give the most dependable results.

4.1 Regression framework

The regression takes the following form:

$$ln(Leave\ share_i) = \beta_1 + \beta_2 ln(Age_i) + \beta_3 ln(Unemp_i) + \beta_4 ln(GDHI_i) + \beta_5 ln(Exp_i) + \beta_6 ln(NonUK_i) + \beta_7 ln(Turnout_i) + \varepsilon_i$$

The regression framework is called a double log functional form, meaning that both the independent and dependent variables are logged. All variables were logged as they were found not to be normally distributed. By transforming the variables to logged, normal data was constructed. *Leave share* is the dependent variable and the percentage of votes for Britain's exit from the EU in each NUTS 3 region *i*. *Age* is the share of 18-40 year olds out of 18-90 year old, *Unemp* is the level of unemployment, *Exp* is the percentage of people working in highest export industry, *NonUK* is the percentage of the population born outside of the UK and *Turnout* is the

percentage of eligible voters who casted a valid vote in the Brexit referendum in each region. A more detailed description of the variables will be presented in section 4.4.

4.2 Data

The selection of dependent and independent variables for the dissertation are based on previous research, economic theory and the data's accessibility. The data was collected from 2015, and were chosen as these were the most complete data sets collected before the referendum. It was collected predominantly from the Office for National Statistics, which is a recognised national statistical institute in the UK. Additionally, some data is collected from HM Revenue & Customs as well as from The Electoral Commission. For statistical purposes, the UK is divided into different Nomenclature of Territorial Units for Statistics (NUTS) areas. 2015 NUTS 3 splits the whole of the UK into 174 areas consisting of council areas in Scotland, unitary authorities in Wales, districts in Northern Ireland as well as the 133 subdivisions in England. In this dissertation, the 133 subdivisions of England will be studied, which consists of counties or groups of unitary authorities (Office for National Statistics, n.d).

4.3 Included variables

Table 1: Variables

Variable	Mean	Median	Standard deviation	Min	Max
18-40 year olds	0.387	0.362	0.08979	0.25535	0.821
Unemployment rate	0.05183	0.048	1.974	0.014	0.12
GDHI	19418	18507	5415	12779	52298
People working in high export industries	0.02908	0.02717	0.01895	0.001764	0.1193
Country of birth not UK	0.1475	0.1028	0.1191	0.02254	0.5387
Voting turnout	0.7259	0.727	0.04849	0.597	0.8393
Leave share	0.5336	0.5517	0.1055	0.2138	0.7228

The variables are unweighted, meaning that they do not account for differences in the region's sizes, resulting in the mean not representing the national mean.

4.3.1 *Age*

The variable *Age* describes the share of the population that is 18-40 years old out of the population that is 18-90 years old for each of the NUTS 3 regions in England. The area with the highest percentage of population 18-40 year olds was Bexley and Greenwich with a percentage of 82.1 percent and the area with the lowest share of 18-40 year olds was Dorset CC with a share of 25.53 percent (Office for National Statistics, 2021a).

4.3.2 *Unemp*

Unemployment rate represents the share of the labour force that is currently unemployed (Investopedia, 2021). This variable describes the unemployment rate for each NUTS 3 region in England. Chorley and West Lancashire had the lowest unemployment rate at 1.4 percent, whilst Wolverhampton was the area with the highest unemployment rate at 12 percent (Office for National Statistics, 2021d).

4.3.3 *GDHI*

This variable describes the Gross disposable household income per head at current basic prices for 2015 (£) for each NUTS 3 region in England (Office for National Statistics, 2021b). GDHI describes the amount of money that all of the individuals in the household sector have available for spending or saving after they have paid direct and indirect taxes and received any direct benefits (Lancashire County Council, 2018). The area with highest GDHI was Kensington & Chelsea and Hammersmith & Fulham, which is commonly seen as one of the wealthiest areas in the London region, with a GDHI of £52 298 in 2015. The lowest GDHI was observed for Nottingham at £12 779.

4.3.4 *Exp*

This variable is the percentage of the workforce working in the top exporting industry for each NUTS 3 region in England (Office for National Statistics, 2019). In 2015, this highest exporting industry was machinery and transport equipment which accounted for 38 percent of the UK's total goods exports (Greene, 2016).

4.3.5 *NonUK*

This variable is the share of the population in each of the NUTS 3 regions in England that were born outside of the UK (Office for National Statistics, 2021c). The area with the highest share of its population born outside of the UK was the outer London area Brent at 53.86 percent. Essex Thames Gateway was the lowest at 2.3 percent.

4.3.6 *Turnout*

The voting turnout describes the share of eligible voters who cast a valid vote in the referendum. This variable is the voting turnout for each NUTS 3 region in England. With an election participation rate of 83.9 percent, Greater Manchester North West was the area with the highest voting turnout (The Electoral Commission, 2019). Manchester had the lowest turnout with 59.7 percent.

4.3.7 *Leave share*

The leave share is the dependent variable and consists of the percentage of votes that were in favour of leaving the EU. The variable was calculated by the number of leave votes, divided by the number of valid votes in each NUTS 3 area. Thurrock, located in the county of Essex, was the area with the highest share of leave votes, 72.28 percent. Lowest share of leave votes was Lambeth, with 21.38 percent votes for leave (The Electoral Commission, 2019).

4.4 Data limitations

There are a few limitations to the data used in this study, which will be discussed below.

Firstly, the data for the percentage of people working in the highest exporting industry were not all divided into NUTS 3 regions, resulting in some data being grouped. For example, the NUTS 2 region Greater Manchester is divided into five NUTS 3 areas. The data used divided Greater Manchester into two areas, which resulted in some NUTS 3 areas being given the same data. A small section of the data was grouped, meaning that it is not likely to affect the overall result of the regression analysis. Moreover, if there were any missing data for 2015, an average was calculated based on the year before and the year after.

Secondly, the dissertation only covers a limited amount of variables and only includes data for England and not the entire UK. The decision to only include England was mainly due to the lack of data for Northern Ireland, Scotland and Wales. Eurostat, which provides statistical information to the members of the EU, had removed large datasets for the UK, as they now have left the European union. This contributed to valuable variables being excluded from the regression, and thus is likely to have led to omitted variable bias. The exclusion of Northern Ireland was further motivated by its history. *The Troubles* and the terms of *The Good Friday Agreement* may have encouraged people to vote differently which would have made finding voting patterns more difficult.

Lastly, there are some limitations to the variables that are useful to highlight. The variable *Age* is the share of the entire population in each area, not only those who are eligible to vote. The variable *GDHI* is not corrected for inequality within a region, meaning that assumptions for individual households are made more difficult. The variable *Exp* includes those working for companies that are not only producing for export consumption but for domestic consumption as well. Additionally, the variable *NonUK* born does not specify whether these people are eligible to vote or if they were born in or outside of the EU, meaning there is uncertainty regarding their citizenship.

4.5 Hypothesis for variables

The hypothesis is to find a negative relationship between the variable *Age* and the dependent variable meaning that a younger population would be in favour of remaining in the EU to a larger extent than an older population. The hypothesis is based on previous research presented in section 3.

The hypothesis is that there would be a negative relationship with the dependent variable and the independent variable *Exp*. This would mean that regions where a larger percentage of its workforce work for the top exporting industry would result in more people voting in favour of remaining in the EU. The terms under which the UK would leave the single market were not determined before the vote, which meant that the deal that would be made post referendum would to a large extent effect the terms under which Britain would export (Deloitte, 2017). As

the EU manages all trade relations with third nations for its members, leaving the EU would affect trade not only with EU countries but with all other countries with whom the EU had a trade agreement with (European Council, n.d).

For the variable *GDHI*, the hypothesis is to find that there is a negative relationship. This would indicate that regions with higher GDHI would to a larger extent vote in favour of remaining in the EU. The hypothesis is based on previous research that suggested that a vote in favour of Brexit was a vocalisation of dissatisfaction from regions that may have been left behind when others experienced economic growth.

For variable *Unemp,* the hypothesis is to find a positive relationship. An increased number of unemployed people of a region would then increase the percentage of votes in favour of leaving the EU. Previous research suggests that, similarly with lower GDHI, unemployment would result in a vote of discontent. If areas with a larger share of unemployment associated the EU with increased immigration, due to the free movement of people, this may have further increased their support for Brexit. This is because, as theory suggests, immigration affects the labour supply meaning it influences the labour market. Though the effect of immigration depends on what skills the labourers have, if migrant workers substitute existing skills it may increase competition on the labour market. In the short term, this would then result in reduced wages as well as increased unemployment which, to a larger extent, affects already low paying jobs (Ruhs & Vargas-Silva, 2020).

The hypothesis is to find a positive relationship between the variable *NonUK* and the dependent variable. This is based on previous research, such as Becker's and Fetzer's (2017), which found that areas that received a lot of labour migration had an increase in anti-EU sentiment. As mentioned in the previous paragraph, migration could short term cause unemployment and reduced wages in certain industries which may cause resentment towards immigration.

The hypothesis for the variable *Turnout* is to find a positive relationship. This hypothesis is based purely on previous research described in section 3.

5. Empirical selection

To analyse the effects the different independent variables have on the dependent variable, a bivariate regression was performed, using Ordinary Least Squares (OLS) regression. The bivariate regression shows the strength of the relationship between one of the independent variables and the dependent variable, by running a regression with each individual independent variable. The bivariate analysis shows how much of the dependent variable can be explained by each individual independent variable alone and if the results are significant enough to statistically prove a relationship (Hoffman, 2019). The results of the bivariate analysis are presented in table 4. Regression analysis is commonly used to determine the relationship between variables, however, it's unlikely that only a single variable affected this outcome meaning that the bivariate test likely suffers from omitted variable bias. Omitted variable bias is when variables that are correlated with the dependent variable are excluded from the regression which results in the error term being correlated with the dependent variable (Hanck, Arnold, Gerber & Schmelzer, 2021). Therefore a multivariate analysis was performed, in order to determine the influence of the multiple independent variables on the dependent variable. This method of regression was performed to reduce the likelihood of incorrectly rejecting the null hypothesis, and to determine which included variables that would best explain the dependent variable. Robust standard errors can be used to account for minor issues with the method's conditions and can therefore be a useful alternative (Hammarbacken, 2016). The model will be run both with and without the robust standard errors to compare the results.

5.1 Econometric discussion

In order to perform a linear regression, some econometric tests need to be applied in order to strengthen the validity of the performed regression. To conclude that the OLS was the best linear unbiased estimator the Gauss Markov assumptions needed to be fulfilled. The Gauss Markov assumptions include six of the classical assumptions. The first one is that the model needs to be linear both in parameters and in the error terms (Hayashi, 2000). With individual scatter plots it is determined the assumption of linearity is fulfilled.

The second assumption is that the population mean for the error term must be zero, since a constant was included in the regression the error term's mean is forced to be zero (Hayashi, 2000). Therefore this assumption is fulfilled.

The third assumption is that the independent variables are exogenous meaning that they are independent of the error terms (Hayashi, 2000). However, since we cannot determine a causal relationship between the independent variables and the dependent variables, only covariation, there is no need to test for endogeneity.

The fourth assumption is that there is no autocorrelation, meaning that the observations of the error terms are uncorrelated with each other (Hayashi, 2000). Since we did not use time series data and there is no natural ordering of the data, testing was not deemed necessary.

The fifth assumption is that the error terms are homoscedastic meaning that the variance does not change for a range of observations (Hayashi, 2000). A white's test was performed using gretl and the null hypothesis of homoscedasticity was not rejected meaning that the fifth Gauss Markov assumption holds. Though the null hypothesis was not rejected, the p-value was just above the limit. This, combined with the research subject, makes it plausible that the regression suffers from omitted variables. When an important variable is left out of a model the effect of the variable is absorbed by the error term and will make the coefficient inefficient and the significance level inconsistent. Therefore the model will be run using robust standard errors.

The sixth assumption is that no independent variables are perfectly correlated with each other (Hayashi, 2000). The test suggests, as shown in the correlation matrix (Table 2), that there is quite high correlation between some of the variables such as that between *Turnout* and *Unemp* as well as that between *NonUK* and *Age*.

Table 2: Correlation matrix

	18-40 year olds	Unemployment rate	GDHI	People working in high export industry	Country of birth not UK	Voting turnout
18-40 year olds	1					
Unemployment rate	0.439036715	1				
GDHI	0.18748407	-0.239321136	1			
People working in high export industries	-0.280191766	-0.029489916	-0.45614258	1		
Country of birth not UK	0.715472968	0.268108118	0.50145479	-0.454094911	1	
Voting turnout	-0.590441529	-0.726033661	0.164845222	0.051420745	-0.402926042	1

However correlation alone is not enough to remove a variable. To investigate this further, a Variance Inflation Factor, VIF, test was performed to check for multicollinearity. Multicollinearity makes it more difficult to determine if the data is reliable. The Variance Inflation Test (table 3) determines if there is a high level of linearity between two or more independent variables by performing a regression with them (Bhandari, 2020). A variance inflation factor (VIF) of 1 would indicate that there is no correlation detected between the variables. A VIF of more than 4 would suggest that there is a need to investigate the cause and a VIF of 10 would mean that the multicollinearity is too high and correcting is needed (Pennsylvania State University, 2018). The variance inflation suggests that there may be correlation as the variance inflation factor is above 1. However, the factor is low enough that it should not be a cause of concern. Therefore further testing may include all variables without concern that the reliability of the test decreases.

Table 3: Variance Inflation test

Variable	Variance Inflation Factor
18-40 year olds	2.072
Unemployment rate	2.08
GDHI	2.353
People working in high export industries	2.238
Country of birth not UK	2.257
Voting turnout	2.658

6. Empirical results

This dissertation aims to further contribute to previous research on the subject regarding what factors influenced the voting pattern in the EU referendum. In the following section, the selected variables will be analysed using first bivariate analysis and analysis of a multivariate regression followed by a multivariate regression including robust standard errors. The multivariate regression is run in order to account for omitted variable bias in the bivariate regression. Though the white's test's null hypothesis of homoscedasticity was not rejected, the multivariate regression is still likely to suffer from omitted variables. Therefore the regression is run again using robust standard errors to account for inconsistency in the significance level, caused by important variables being excluded. However, the model will suffer from inefficient coefficients.

6.1 Bivariate analysis

Table 4: Bivariate Analysis

Variable	1	2	3	4	5	6
18-40 year olds	−0.445620***					
	0.000					
Unemployment rate		−0.0672400				
		0.1888				
GDHI			−0.609792***			
			0.000			
People working in high export industries				0.188366***		
				0.000		
Country of birth not UK					−0.183458***	
					0.000	
Voting turnout						0.828155***
						0.000
R-squared	0.252346	0.013145	0.34064	0.487421	0.340619	0.057533
Number of observations	133	133	133	133	133	133

*Note: *** indicate significance at a 1% level*

The variables are shown in the rows of the figure and columns (1) through (6) show the coefficient for each independent variable with the dependent variable *Leave share*. In column (1), the demographics of age is related to the leave share. This result implies that an area with a younger population would to a larger extent vote for the UK to stay in the EU, due to the positive relationship between the independent variable and the dependent variable. In column (2), the

unemployment rate is related to the leave share. However the test is not able to verify any relationship between the two, because the variable is shown to be insignificant with a high p-value. This does not mean that there is not one, but with this test and this data we are not able to verify it. *GDHI* is shown in column (3), and the results of this test indicate a negative relationship between the variables. These indicate that all else equal, an increase in GDHI would result in a decrease in votes in favour of leaving the EU. In column (4), the percentage of people working in the industry with the most exports is shown which again suggests that there is a relationship. According to the test, an increase in the percentage of people working in the highest exporting industry would result in an increase in votes in favour of leaving the EU. The variable *NonUK* is shown in column (5), and according to the bivariate analysis, a relationship is once again verified. The results suggest that an increase in the percentage of people born outside of the UK, all else equal, would decrease the votes in favour of leaving the EU. Lastly, in column (6), we can see whether the test is able to verify a relationship between voting turnout and votes in favour of leaving the EU. The test suggests that there is a relationship and that an increase in the voter turnout, all else equal, would result in an increase in share of votes in favour of leaving the EU.

6.2 Multivariate analysis

Table 5: Multivariate analysis

Variable	1	2	3	4	5	6	7	8
18-40 year olds	−0.445620***	−0.478486***	−0.344327***	−0.269323***	−0.237089	−0.182024***	−0.181529***	−0.209227***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Unemployment rate		0.0558418	−0.0821584**	0.0259224		0.0341572		
		0.2471	0.000	0.5113		0.4561		
GDHI			−0.612567***	−0.370966***	−0.331826***	−0.420087***	−0.433814***	−0.449037***
			0.000	0.000	0.000	0.000	0.000	0.000
People working in high export industries				0.0978368***	0.094689***	0.0829666***	0.0808845***	0.085482***
				0.000	0.000	0.000	0.000	0.000
Country of birth not UK					−0.0303767	−0.0228661	−0.0217456	
					0.2253	0.3706	0.3928	
Voting turnout						0.705339**	0.588792**	0.621373**
						0.000	0.000	0.000
R-squared	0.252346	0.26004	0.553238	0.617974	0.620602	0.637112	0.635489	0.633685
Number of observations	133	133	133	133	133	133	133	133

*Note: ** and *** indicate significance at a 5% and a 1% level*

In column (1), the bivariate tests for a relationship between the independent variable *Age*, and the dependent variable *Leave share* is repeated and again shows a negative and significant relationship. In column (2), the *Unemp* rate is added. However, though a positive coefficient value is suggested, it is not possible to prove a relationship as it is not significant. In column (3) *GDHI* is added and the test finds that there is a significant negative relationship. When including *GDHI* in the regression, *Unemp* becomes significant and negative. In column (4) *Exp* is added and shows a positive and significant relationship. When the *Exp* is added, *Unemp* once again becomes positive and insignificant. In column (5), *Unemp* is removed and *NonUK* is added. *NonUK* is shown to be negative but not significant. The other variable's coefficients decrease while R-squared increases slightly for the regression. In column (6) *Unemp* is introduced again and *Turnout* is added. *Turnout* is positive and significant, while *Unemp* and *NonUK*, remain insignificant. In column (7), when the regression is run again but without *Unemp*, R-squared decreases slightly and the coefficient for voting *Turnout* is decreased from 0.705 to 0.589. In column (8), *NonUK* is also removed from the regression, which decreases R-squared further and increases all other coefficients. R-squared is the highest in column (6) indicating that *Unemp* and *NonUK* should be included even though they are statistically insignificant.

6.3 Robust standard error

Table 6: Robust standard error

Variable	1	2	3	4	5	6	7	8	9
18-40 year olds	-0.658880***	-0.775174***	-0.577616***	-0.470750***	-0.543783***	-0.479295***	-0.475020***	-0.405174***	-0.460468***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Unemployment rate		0.127083***	-0.017064	0.0130651	0.0137652	0.0402798			
		0.2471	0.668	0.7367	0.7247	0.3627			
GDHI			-0.560076***	-0.383161***	-0.403776***	-0.435657***	-0.451690***	-0.436015***	-0.394542***
			0.000	0.000	0.000	0.000	0.000	0.000	0.000
People working in high export industries				0.0761834***	0.0789147***	0.0755049***	0.0731340***	0.0704434***	0.0747066***
				0.000	0.000	0.000	0.000	0.000	0.000
Country of birth not UK					0.0290192	0.0253693	0.0260783		
					0.3192	0.3848	0.3712		
Voting turnout						0.395116	0.262035	0.286323	
						0.2039	0.3385	0.2903	
R-squared	0.345769	0.381954	0.619327	0.655663	0.658081	0.662485	0.660232	0.658367	0.655357
Number of observations	133	133	133	133	133	133	133	133	133

*Note: *** indicate significance at a 1 % level*

In column (1), the bivariate test for a relationship between the independent variable *Age* and the dependent variable *leave share* is repeated, but with robust standard errors. Once again, the variable shows a negative and significant relationship with the dependent variable. In column (2) *Unemp* is added. This time it shows a significant positive relationship. In column (3), *GDHI* is added and the test finds that there is a significant negative relationship. When *GDHI* is included in the regression, the variable *Unemp* becomes insignificant. In column (4), the variable *Exp* is added and is found to have a positive and significant relationship with the dependent variable, whilst *Unemp* remains insignificant. In column (5), *NonUK* is added and is positive but not significant. In column (6), *Turnout* is added and is found to have a positive but not significant relationship with the dependent variable. *Unemp*, *NonUK* and *Turnout* are not significant when all variables are included in the regression, whilst *Age*, *GDHI* and *Exp*are all significant. In column (7) the regression is run again but the variable *Unemp* is removed, R-squared decreases only slightly and the coefficients for the other variables change slightly. In column (8), *NonUK* is also removed which again decreases R-squared and the change has a slightly larger impact on the other coefficients. In column (9) the last insignificant variable *Turnout* is removed which again reduces R-squared a little bit more as well as changes the coefficient for the significant variables. R-squared is the highest for column (6), indicating that all variables should be included in the regression, including those that are not significant. However, the explanatory power of the regression is not greatly impacted by either insignificant variable.

7. Discussion of the results

The purpose of this dissertation is to examine what factors may have affected the results of the EU referendum and then relate these findings to the expectations for the variables. In the following section we will do the latter.

The bivariate test shows that the variable *Age* has a negative relationship with the dependent variable. This is in line with the hypothesis of this dissertation which is that a younger population share would decrease the votes in favour of leaving the EU, which also supports previous research findings such as that of Baldwin and Wyplosz (2021) as well as the study by Finlay et. al. (2020). The bivariate analysis shows a negative relationship with the variable *Unemp* with a

coefficient that is notably smaller than for the other variables. This relationship is also not statistically significant, meaning that we are not able to prove this relationship. Had the relationship been statistically significant it would not have been in line with previous research. Furthermore, the bivariate analysis shows a statistically significant, negative relationship between the variable *GDHI* and the dependent variable. This supports the hypothesis and suggests that on average an increase in household income would decrease the share of votes in favour of leaving the EU. This is also in line with previous research finding that lower income households voted in favour of leaving. Moreover the bivariate analysis shows a statistically significant positive relationship between the dependent variable and the variable *Exp.* This does not support the hypothesis as this suggests that an increase in share of the population that work in the top export industry would, all else equal, increase the votes in favour of leaving the EU. A possible explanation for this may be that this variable is correlated with an omitted variable. In the bivariate analysis the variable *NonUK* is negative and significant. This is not in line with the hypothesis as this indicates that if a larger percentage of citizens in a region are born outside of the UK, less people would vote in favour of leaving the EU. Finally, the bivariate analysis shows a statistically significant positive relationship between the independent variable *Turnout* and the dependent variable. This supports the hypothesis and suggests that an increase in the voter turnout increases the likelihood of a larger share of the votes in favour of leaving the EU.

The bivariate test was followed by a multivariate test to control for omitted variable bias. When all the variables are put into the multivariate regression, the variable *Age* stays significant for all regressions. As previously mentioned it is in line with previous research that suggests that a younger population is less likely to favour leaving the EU. The coefficient however decreases drastically compared to the bivariate test suggesting a weaker effect on the dependent variable than indicated by the results from the bivariate analysis.

The variable *Unemp* stays statistically insignificant for all regressions, apart from column (3), which means that we are not able to prove a relationship between the independent variable *Unemp* and the dependent variable. This is again not in line with previous research that suggested that unemployed were more likely to vote in favour of Brexit. *Unemp* becomming significant and that its coefficient turns negative when *GDHI* is added to the regression, could be

explained by the negative correlation between unemployment and GDHI, as shown in the correlation matrix. The two variables, to some extent, cover the same socio economic status of the inhabitants of a region and could therefore produce unreliable results.

Furthermore, the variable *NonUK* is no longer significant when it is put into a regression with the other variables. This may be the case when a regression suffers from multicollinearity, however, as shown in the VIF test, this is not the case. Therefore, it may be that the other variables simply better explain the dependent variable than the variable *NonUK*. This is not in line with the research that suggested that anti EU sentiment grew in areas that received a lot of labour migrants. On the other hand, the research that suggested this was conducted right after a great inflow of labour migrants and was based on specific countries unlike this data that included all that were born outside of the UK . Furthermore, it may be that the immigrant's skills did not substitute the existing skills in the regions, meaning that they would not compete for the same jobs and reduce the wages. As this variable only takes into account how many people in an area were born outside of the EU, the results cannot be compared to previous research that highlighted people's views of migration and how important they found the topic of migration to be. Therefore, this analysis cannot be used to strengthen nor weaken results presented in earlier research of this topic.

GDHI remains negative and significant in all regressions which again supports the hypothesis that households with a higher GDHI to a larger extent voted in favour of remaining in the EU. As mentioned before, this supports previous research findings.

The variable *Exp* is found to have a positive and significant relationship with the dependent variable. This is not in line with the hypothesis as it suggests that the regions where a larger share of the population works in the top exporting industry, to a larger extent, supported Brexit. If the variable had turned out to be insignificant, it could have been explained by the fact that other variables affected the dependent variable more. However, though not impossible, it is unlikely that those working in the top exporting industry, due to them working in said industry, would have to a larger extent supported Brexit. It is unlikely as most agreed that Brexit would probably have a negative effect on UK exports. The results may therefore be explained by the

variable being correlated with an omitted variable. If the regions where a larger share of the population works in the top exporting industry also for example has a larger share without higher education, this could produce misleading results. This due to the fact that previous research has found a positive relationship between a lower degree of education and leave share. However, it could also be explained by the fact that the leave campaign pressed that they would get new, and possibly better deals, which means that it would not be seen as an issue but rather as something beneficial to the industry. In this case the significant result may be accurate. Finally, the multivariate analysis again shows a statistically significant positive relationship between the independent variable *Turnout* and the dependent variable. As previously stated this is in line with the hypothesis and previous research that suggests that an increase in the voter turnout increases the likelihood of a larger share of the votes in favour of leaving the EU.

With each variable added, the coefficient of the variables decrease, suggesting that the strength of the explanatory variables are affected. Therefore the exact value for the coefficient may be perceived as less important. Nevertheless, the strength of *Turnout* is the greatest in all regressions run and *GDHI* remains relatively strong. The coefficient of *Exp* is quite low, suggesting that though significant the impact is not great.

R-squared increases with every variable added indicating that even the variables that are not significant should be included in the regression. With all variables included, the regression is able to explain the variance in the referendum results by 63.7 percent. However, there is little difference in the R-squared value for column (6), (7) and (8) suggesting that including the insignificant variables does not increase the explanatory power for the regression greatly. The R-squared value suggests that there is around 36.3 percent of the variance in the referendum results that we are not able to explain with our regression.

It should also be considered that it is not only the bivariate analysis, but also the multivariate analysis that possesses a great probability of omitted variables, and therefore omitted variable bias. Variables that should have been included were undoubtedly excluded for various reasons. Some variables that should have been included are level of education which has been shown by previous research to covariate with the dependent variable, and party sympathy but there are

unquestionably many more. To account for possible issues, caused by omitting important variables, the regression was run including robust standard errors.

When the regression is run, using robust standard errors, the results differ from that of the multivariate analysis without them. The strength of the impact of the variable for *Age* increases and suggests that a younger population to an even greater extent decreases the votes in favour of leaving the EU. The variable remains significant for each run regression. This again supports the hypothesis and previous research that suggested that a younger population would to a larger extent be in favour of remaining in the EU. The variable unemployment is positive and significant when it is only run with the variable *Age*, unlike in the multivariate regression without the robust standard errors. When *GDHI* is included unemployment becomes negative and insignificant. However, in column (4), it once again becomes positive. This result, as in the multivariate regression without robust standard errors, could be explained by the fact that they both to some extent cover the socio economic status of people in the region. This could explain the negative correlation, as seen in the correlation matrix, between *Unemp* and *GDHI*. GDHI is, just like before, significant in each run regression and supports the hypothesis that higher GDHI is associated with less votes in favour of leaving the EU.

When the regression is run with only 18-40 year olds, unemployment and GDHI, the impact of GDHI on the dependent variable is smaller than the same regression without the robust standard errors. However, when more variables are included the impact is about the same as before. As before, the variable for people working in the highest exporting industry is negative and significant. This again does not support the hypothesis and suggests that regions where a larger percentage of people work in the highest exporting industry to a larger extent supports Brexit. Although, as stated previously, the impact of the independent variable on the dependent variable is small and the results could be explained by a correlation with an omitted variable. However, as mentioned before, the results should not be dismissed either, as the leave campaign promised new and better trade deals. Further research should be conducted to investigate this finding further.

Similarly to the previous results, the variable *NonUK* is not significant when it is put into the regression with multiple variables. The biggest difference between using the robust standard errors, compared to the previous results, is that the variable voter turnout is no longer significant. The coefficient has also greatly decreased from 0.589 at its lowest to now 0.262 at its lowest. The previous regression supported the hypothesis that suggested that an increase in voter turnout positively covariate with an increase in votes in favour of leaving the EU. However, this relationship was not proven when the robust standard errors were added. Furthermore, when the robust standard errors are included, the variables *Age* and *GDHI* have the strongest effect on the dependent variable.

Though the new robust regression has one less significant variable, the R-squared value has increased slightly. The explanatory power of the regression remains strongest when all variables are included. It is then able to explain 66.2 percent of the variance in the dependent variable *Leave share*. As stated before, the explanatory power of the regression changes only slightly when removing the insignificant variables. Even when voting turnout is removed, R-squared is 65.6 percent which is higher than the R-squared value for the previous regression when all variables are included, suggesting that the model with robust standard errors better explained the variation in the dependent variable.

As this regression is based on aggregated data, one should be cautious before drawing conclusions on how individual voting patterns were influenced by these variables. The analysis was not able to prove all relationships that previous research had found, which may lead to questions regarding how the data was analysed. For example, by looking at how unemployed and employed people voted, previous researchers concluded that unemployed people voted in favour of Brexit. While this may be beneficial, to the extent that it focuses more on the individual, it does not take into account that there may be other variables that influenced their voting patterns. To increase the accuracy of the model, it's suggested that one should instead use smaller divisions than the 133 NUTS 3 regions, as well as adding more variables to further decrease omitted variable bias. Furthermore, it is suggested that further research should be done regarding the top exporting industry to review the findings of this analysis.

8. Conclusion

Since the results of the EU referendum in 2016 were presented, many researchers have tried to explain what factors influenced the voting pattern. According to the Treasury's forecast, published during the campaign, leaving the EU would come with great economic costs for individual households and slow down the country's economic growth. Still, the vote ended with a majority voting in favour of Brexit. To find factors that may have influenced this result, this dissertation included a regression with multiple variables that were deemed likely to have had an impact. The decision on what variables to include was based on previous research as well as economic theory and availability of data. This dissertation contributes to the field by including new variables as well as different versions of those previously used.

The bivariate and multivariate analysis concluded that the variable unemployment was not significant for either analysis and the variable *NonUK* became insignificant when the other variables were added in the multivariate analysis. These results defy previous research findings and could indicate that these factors may not be as important as previously suggested. However, the inconsistency could be explained by the use of different datasets, as well as different approaches to analysing the effects of the factors. This means that it should not be concluded that these factors did not influence the voting pattern, only that this research was not able to prove it. In the multivariate analysis without robust standard errors the variables *Age*, *GDHI*, *Exp* and *Turnout* had a significant effect on the dependent variable. Lower age and an increase in GDHI decreased the share of leave votes, while an increase in voting turnout was related to an increase in share of leave votes. *Age*, *GDHI* and *Turnout* were all in line with the hypothesis and previous research. However, the variable exp was not in line with the hypothesis as it suggested that an increase in people working for the top exporting industry was associated with a region to a larger extent supporting Brexit. The writers suggested that this could be explained by the variable being correlated with an omitted variable. However, it may also be a sign of success for the leave campaign. Further research would be needed to make any conclusions regarding these results. To account for a possible effect on the reliability of the results caused by omitted variables a multivariate regression with robust standard errors was run. This caused voter turnout to become insignificant as well and suggested that age had a bigger effect on the dependent variable than the original multivariate analysis suggested. Furthermore, the R-squared value was larger when

using the robust standard errors indicating that the model could better explain the variation in the dependent variable leave share.

As this is based on aggregated data, one should be cautious before drawing conclusions on how individual voting was influenced by these variables. It is also crucial to mention that though the multivariate analysis is performed to reduce the likelihood of omitted variable bias, the model most probably excludes variables that should have been included. Furthermore, it is important to mention that although England's population constitutes the majority of the UK's population, the findings of this research cannot be used to draw conclusions about the whole of the UK as voting patterns may differ. Moreover, the accuracy of the regression could be improved by looking at data collected for smaller divisions than the NUTS 3 regions, for example, data covering Local Administrative Units (LAU).

Studying Northern Ireland, Scotland and Wales individually could be beneficial as they may have different interests and influences, such as Northern Ireland's history. Conclusively, it would also be interesting to see how these factors that may have influenced the results have changed after the Brexit referendum.

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