Erasmus University Rotterdam

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Bachelor Thesis Economics and Business Economics

The Impact of Brexit on British Fishery Competitiveness

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Abstract

This paper discusses the effects of Brexit on the efficiency and productivity of United Kingdom (UK) fisheries following the *de facto* exit of the UK from the European Union (EU) and their preferential deals. The data for fisheries were retrieved from the ORBIS database and further supplemented using the official European Commission and UK government data. To estimate the effects on current UK productivity, a counterfactual analysis was performed using the synthetic control method comparing five other European countries: France, Spain, Italy, Netherlands, and Norway. The paper establishes the importance of labour, productivity, and financing in the fisheries market, all factors which are within the regulatory changes that Brexit introduced. The scope of this research is in business economics and industry performance. The fishing industry is analysed on a micro- and macroeconomic scale through qualitative and quantitative means. The synthetic control counterfactual within this paper, indicated that the UK has performed worse relatively to a position where it would not have left the EU, however it achieved greater stability.

Introduction

The choice to leave the European Union has been one of the most discussed and deeply divisive affairs in the United Kingdom since the troubles, and the Falklands campaign. A decision that naturally diverged the attitudes of European countries and the UK, it gave rise to the academic opportunity in studying the economic implications of the new state of affairs. The vote materialized the systematic and regional inequalities that are present in the UK (Fetzer, 2020). Lower income citizens voted leave, despite said communities being most vulnerable to change. Paradoxically, the 'losers' of Brexit voted most unanimously to leave, while wealthier service industry voters supported the choice to remain despite their industries relative advantage in terms of vulnerability (Alabrese et al., 2019). This paradox urges evaluating the realities of Brexit further. What are the real changes in terms of efficiency and productivity for the UK? What are the important factors for industries with cultural heritage? How does Brexit (dis)advantage the industries that supported it the hardest?

A vote such as Brexit was a vow for national pride, and patriotism to a lot of voters, supported by the words of PM Boris Johnson on "Extricating [Britain] from the EU's extraordinary and opaque system of legislation" (Kettle, 2022). As discussed previously, income was the foremost determinant for Brexit, even between Eurosceptics and liberals' there is a positive trend between income and voting remain. One industry that is tied to British cultural identity, and that represents a lower income population is the fishing industry which to no surprise, maintained a 92% support for leaving the EU in 2016 (University of Aberdeen, 2016). This can be further seen in **figures 1.1 & 1.2** where the light green areas of fishery clusters correspond to counties that voted 'leave', this is seen in Somerset, Cornwall and Lincolnshire. The promised benefits of Brexit for fishers were in eliminating the inefficiencies of EU regulations and enforcement of water rights for fishing, an antiquated measure of control (Smith, 2021). The degree of success regarding these gaols is core to the research of this thesis.

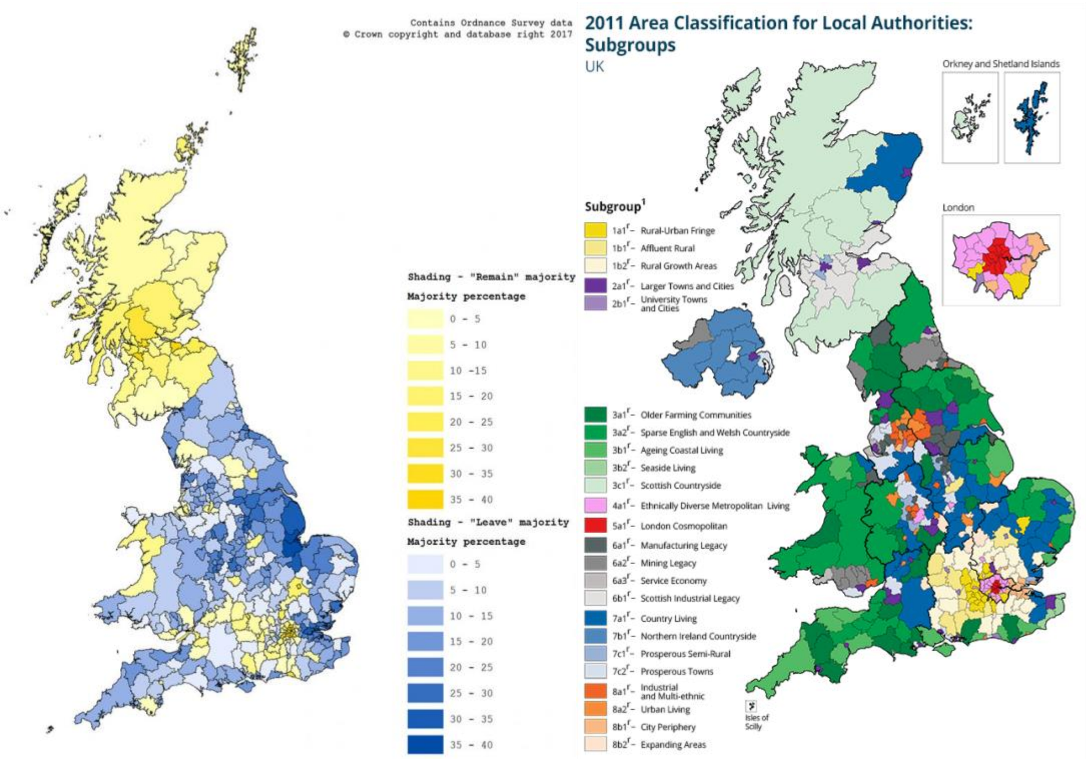


Figure 1.1 & 1.2: *Side by side comparison of the UK Brexit vote (left) with leave in blue and area classifications (right) with 'seaside living' in light green. Source: University of Oxford (2017) and Office for National Statistics (2018) respectively.*

The production of fish is classified in the primary sector, like forestry or mining it is the provision of a basic resource. The Food and Agriculture Organization of the United Nations (FAO) is the leader in worldwide data for this sector, and they firmly distinguish between maritime food resources and land-based ones. To elaborate the former, Aquaculture is the breeding and farming of fish in ponds, separated waters, or terraformed areas. Fisheries, most often refer to enterprises harvesting seafood and fish for processing or sale in wild waters (FAO, 2020). Historically the latter has been the sole method of procuring fish, but in the past 40 years aquaculture has expanded to fit demand. Traditional fisheries have been at a stable level of production since the 1980's, while aquaculture which represented 7% of all catches in those years, has grown to yield over 40% of the net market output for fish (Kierath, 2018). These are the main categories of provision for the seafood trade, and it is relevant to notice their trends, however in many countries they are interchangeable (FAO, 2022).

The object of key importance to the provision of fish is the specificity of fish as a commodity. Firstly, in the case of traditional fishing, available supply is not directly visible unless an expense is taken by a company to procure it. In essence, until one throws the net into the water, it is unknown how much supply there will be. The works of Munro and Scott (1985) underlined how fish in the wild are a renewable resource which has a capacity for growth. With a growing population and incomes globally, one can expect that fish demand will keep on increasing which would conflict with the limitations of traditional fish supply (Vaughan, 2021). Aquaculture has mitigated scarcity and allowed economies to meet market demand, which is where their interconnection comes from, but much of aquaculture still relies on wild catch for feed. Aside from the issues of sustainability and health, at the base level fisheries must operate in efficient ways, uninterrupted by foreign policy restrictions that would disadvantage fair pricing and delivery time through tariffs and bureaucracy. The previous discussion of Brexit leads to the penultimate research question of this paper, namely: "**To what extent has Brexit impacted the profitability and efficiency of British Fisheries**".

The thesis will research findings of academics on both Brexit and the determinants of successful fishery operation. Using this information, a baseline model will be established that regresses financial metrics on profitability using thousands of Companies from select European countries. Following this, a counterfactual analysis will be performed using synthetic control on these countries data. The method used will weigh observable characteristics of European countries to simulate a British counterfactual and measure relative performance metrics for profitability and efficiency in absence of Brexit.

Theoretical framework

Setting the groundwork for this study, some industry and study related terminology must be elaborated. Fisheries, which were distinguished in terms of wild catch and aquaculture are the main object of study for this paper. The fishery relies on a specific harvest, usually quantified in weight which is approximately equal to the interchangeable term biomass. "Traditional fishery" is the term used to refer to all non-aquaculture productions, which apart from some shellfish and molluscs harvest fish from legally recognized fishing waters (Encyclopaedia Britannica, 2019). These areas have water rights which permits fishermen from a specific country to fish in and sets limits on biomass harvested by vessel category. Aside from these terms, all data published by fisheries uses standard accounting and financial terminology for profits, revenues, and ratios.

The Brexit relevant terms include timeframe, scheme, and economic terminology. Timeframe is relevant to the academic and non-academic sources that are referenced because Brexit has been in a state of change since 2016. The papers studied in this thesis vary in degrees of information asymmetry, considering their differing dates of publication. It is important to remember that Brexit went through several changes to its scheme in the past 6 years. The referendum was at first intended to either direct a hard Brexit or a soft Brexit. This referred to the level of isolation and termination of bilateral agreements between the EU and UK. The idea of a hard Brexit was in essence a termination of most shared agreements and drawing up new ones where it would be beneficial or necessary for the UK. The soft Brexit scheme was focused on distancing the UK from the EU formally, with mostly small alterations to regulation, while maintaining agreements that the government did not see as disadvantageous (Scott, 2021).

The important factor to both the scheme and timeline of Brexit from the BBC (Edington, 2020) is the following. Brexit officially came into effect on the 31st of January 2020, and in practice on the 31st of December. Following four years of negotiations and discussion, fishing rights still had not been set, which is unsurprising for an industry that is characterised by a lack of enforcement within this parameter. A lesser fact, which is still important is that the UK does not have to obey EU laws on state aid, meaning that they can help failing industries without needing to consult the EU (Fisher, 2019). This is a factor that inspired a lot of marketing for the campaign, despite the lack of statement on what will be its replacement. Lastly, the customs union and border control introduction began in January 2021, followed by a now expired further transition into the new border controls and customs (Centre for European Reform, 2022). What this means is that Brexit was not an immediate effect, it is a process of continuous change and introduction of new regulation. This aspect makes it important to disclose that the degree of fluctuations of transition are relevant to businesses performance, the core of this paper.

What is likely to be a source of deviations, especially considering the real date of 2020 will be the war in Ukraine and COVID. Naturally other factors like the turmoil of U.S politics following Donald Trump's presidency, or the disturbance in African economies and Asian ones from insurgencies in Ethiopia, Myanmar and Nigeria also pose a risk at earlier dates. These shocks influence the world economy and political stage, hence white noise could be expected for production metrics in panel studies. Specifically, COVID and the war in Ukraine are highly important, this study extends to 2021 which relates to the latter. Ruiz-Salmón et al. (2021) discussed this issue, outlining the drop in demand for seafood and unemployment in the sector. The employment loss can be controlled for; however, demand side implications are quite vast. They cited future opportunities for sustainability investment, which is a likely direction in the future. Nevertheless, such changes will take time, and are materialize benefits over longer periods then what is considered for this thesis.

The literature studied in this research pertains to the development of maritime food production and the fishing industry, followed by an analysis of case studies and articles on the developments of Brexit. Fisheries and Aquaculture have been studied for business competitiveness and market dynamics since the 80's, while recent research has worked to optimize profitability and ecology. Reiterating the introduction, ecological capacity is a supply-demand mechanism, hence such papers can establish explanatory power to findings further in the report. To establish the exact nature of how fisheries operate and the specific drivers of this industry, will help embed potential methodologies and suitability for this research on Brexit.

Fisheries and Aquaculture

The paper "The Economics of Fisheries Management" (Munro & Scott, 1985) breaks down two core ideas: the limits to wild catch procurement in fishing and gives an idea of past government intervention efforts within the market. The paper looked at biomass consumption, effort, and sustainability of consumption. Economic contribution was estimated by the authors using present value through a welfare perspective described by the function $PV = \int_0^\infty e^{-\partial t}\pi\big(h(t), x(t)\big)dt$ where delta ia the social rate of discount, h the harvest rate and x the quantity of biomass (fish harvested by weight). In the above function profitability is elaborated as follows $\pi(x, h) = \big(p - c(x)\big)h$. This is obviously a short run function as overharvesting should lead to depletion in the long run, which is considered through optimizing harvest using a Hamiltonian. This method optimizes "control" under the assumption that harvest quantity is the extent of government regulation. Further, the study looks at predatory and bottom feeding species, as the constraints for optimal output.

The function for present value of economic contribution per fishery is valid within this model, it is limited however by the focus on intra-economy regulations. Fisheries are subject to the sharing of water rights with other regions, foreign policy, and bilateral agreements with other countries. Likewise, there are also labour cost effects that naturally differ depending on the countries migration policies. In the case of Brexit, metrics extend from employment, to productivity, and cost efficiency. Brexit was motivated to a large extent by regaining control, in this case of fishing areas, while enduring the business costs of increased labour and frictions (Biedermann & Somai, 2016). Whether this balance approach was effective should be evident from efficiency metrics and overall performance.

The Second paper discussing Fisheries in the UK is "Management of the UK Mackerel Fisheries" by Whitmarsh and Young (1985). It looked specifically at mackerel, which at the time become the most prevalent harvest for UK fisheries. The authors focused on past attempts at regulation and the issues that affected the efficiency of mackerel harvest. Most importantly, the paper outlined how fishing clusters in the UK have suffered issues of unemployment and systematic retardation in development. In the mid-20th century, the government prioritized regulating harvests within their waters which in term disadvantaged local producers as they were at greater risk of legal persecution, while foreign vessels could dock abroad avoiding government agents.

This seemingly antiquated piece of literature presents an integral issue with British management of fisheries. The same issues of unemployment, trying to regulate and control water rights for UK fishermen have been the drivers of the Brexit referendum for fishing communities. Albeit qualitatively, the paper by Whitmarsh & Young (1985) ignores the issue of specialization, rather blaming the use of British waters by other countries for their lack of domination within the market. It is important to realize that motivations for Brexit are not new, rather they seem to repeat the frustrations that the industry faced for over 40 years. According to the authors, the British regulation had negligible benefits since for the competition, technological development compensated legal disadvantages. If this was true, increasing the regulation would indeed be the solution, but it seems to be the opposite. Increasing regulation and control within British fishing areas did not lead to fishermen outperforming their European competitors, which is evident from their dissatisfaction in pushing for Brexit. It is credible to theorise that Whitmarsh & Young (1985) were wrong, and that increasing regulation rather disadvantaged British fisheries.

With these papers in mind, an initial hypothesis is formulated. Using Munro & Scott (1985) one has a baseline for individual fishery cost and performance. The theories of Whitmarsh & Young (1985) associated, the success of a fishery to a large extent by water access, trade tariffs and labour costs. The findings of these authors faltered in light of newer data, hence **Hypothesis 1:** *"The introduction of Brexit regulation affecting labour, and ability to harvest have had a negative effect on profitability and efficiency of British fisheries"* seeks to test the alternative to their statement. Treatments of labour costs and harvest quantity on profits can be performed, in the former case with direct effects, and the latter case with counterfactual analysis on harvest and profits. The years 2016 and 2020 are of focus, as the announcement and the beginning of real regulatory changes for UK businesses with border controls and customs respectively.

Brexit and the value-chain

To understand the degree of potential cost effects, one can start looking at the hard Brexit scenario, which is best portrayed on a macroeconomic scale in the paper "The implications of Brexit for UK and EU Regional Competitiveness" (Thissen et al., 2020). The new deal outcome was modelled on existing commonwealth country agreements, and prioritized distancing the UK from following World Trade Organization (WTO) rules. The paper outlined the multiplier effect issue and used a novel approach to estimate the direct effect of new customs for goods. These new agreements meant that not just the finished good changes in cost, because costs multiply based on the production and trade of components. In the case of fisheries, if new tariffs relate to fishing equipment, vessel maintenance, bait, or other direct and indirect materials necessary for fishing, then the increase in price is not greater than the flat percentage of a new tariff on the finished product. The multiplier effect is a value-chain process, which relates to the fact that production is based on supply chains that have interconnected nodes affecting one another (Tardi et al., 2022). Like a food chain, the action on one node travels downstream all the way to the consumer of the good, making every increase in cost along the chain, a source of inefficiency.

The findings of this paper indicated that the UK is much more cost sensitive and would suffer loss of competitiveness relative to the EU. In the case of fishery and aquaculture, the costs of fishing operations decreased in the hard Brexit scenario by 0.7 % for the EU while increasing by 6.4 % for the UK. This finding is in line with the general trend of most sectors in the British economy, with significantly increasing costs of production across the UK. The rules imposed over the past year have been customs, and labour laws which despite transition and exceptions for fisheries have distanced the UK from the EU and potentially increased costs, if one is to rely on the implications of these findings.

The paper above draws effective conclusions and findings that demonstrate the UK's value chain being highly integrated into the European ecosystem (Thissen et al., 2020). A potential source of ambiguity that can occur when studying real Brexit transition data is that of Behavioural factors and timing issues from policy time lags. Behavioural factors can be defined by the attitudes and agent responses to changes in structure, operation, and expectations due to Brexit. Agents, which refer to anyone who might invest, consume, or act within the economy, might forecast, or expect specific changes and act differently than expected. The factor of timing, relevant to behavioural changes, can be seen as the delays and inefficiencies that result from changing systems.

A paper that has delt with recent Brexit data is with the most recent “What can we know about the cost of Brexit so far?” by John Springford (2022), commissioned for the Centre of European Reform (CER). The paper uses a doppelgänger approach, which aimed to compare the UK to an equivalent UK that has not left the EU. This approach works by isolating changes in output and metrics such as import prices, GDP, and capital investment, then assuming they were kept at a pre-Brexit level. This paper found that by the end of 2021, a shortfall of 13.6% in total goods trade, and 13.7% in fixed capital formulation was present in the UK. Import prices following the referendum have been significantly higher for the UK, which couples with the 2020 Customs introduction, has further distance the UK from its doppelgänger. GDP has fallen behind an approximate basket of 22 advanced economies by 4.9% seen in **Figure 2.1** from the report. Service trade was the only metric of surplus, which is 7.9% above its doppelgänger. Once more it seems that Brexit has quite explicitly, benefitted those who did not vote for it, and disadvantaged those who supported it.

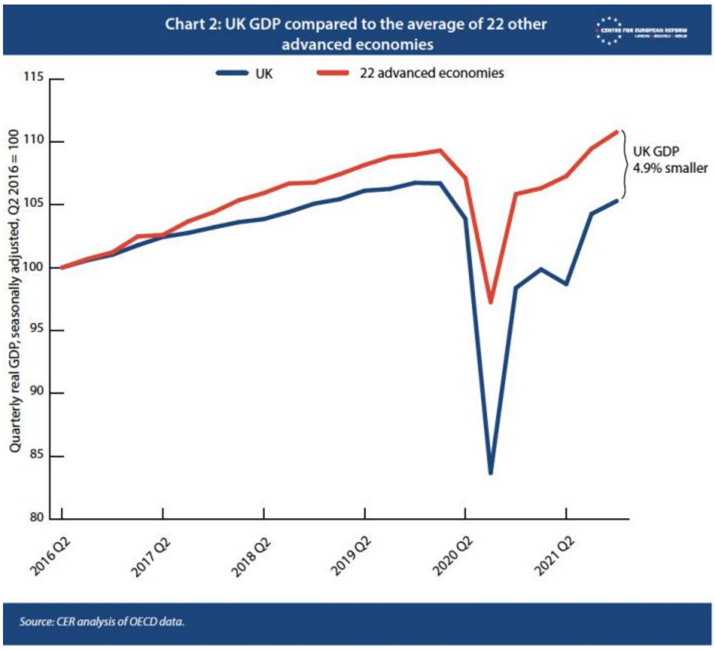


Figure 2.1: *Doppelgänger counterfactual of UK real GDP compared to 22 advanced economies selected through algorithm for representativeness from Springford (2022).*

The next article studied “Impact of the Brexit Referendum on UK Employment: A Synthetic Control Method Approach” (Papyrakis, Pellegrini, & Tasciotti, 2022) effectively used a Brexit relevant methodology. The synthetic control method used is quite novel and increasing in use for econometric impact evaluation of policy changes. Like the approach of Springford it creates a hypothetical counterfactual of a subject that had an intervention by weighing unaffected groups using the observable characteristics. The subsequent synthetic counterfactual is using an algorithm that simulates the treatment group pre-intervention, and results in a doppelgänger of the treated subject in a situation where they were hypothetically not treated. The contribution of this paper, stems from their effective use of this method on Brexit and shows its ability to control for time variant confounders.

This study indicated no significant difference in the unemployment following Brexit between the factual UK and it's non-Brexit counterfactual. Nevertheless, it will be considered in the research section; the Papyrakis, Pellegrini & Tasciotti (2022) paper posed several errancies, which encumber validating their conclusion. The study only looked at periods from 2012 to 2020 and from 2008 to 2019, however considering the significance and precision of their report this can be used as a standard. Regarding this, it is relevant that the authors set the date in 2016, even though as previously mentioned Brexit measures did not come into place until much later (University of Oxford, 2022).

The final pillar from the core academic sources supporting this research is "COVID-19 Provides an Opportunity to Advance a Sustainable UK Fisheries Policy in a Post-Brexit Brave New World" by Kemp, Froese & Pauly (2020). This Paper brings in the applicability of fisheries, and the revealed changes from Brexit alongside studies on covid-19. The paper highlights how sustainability must be prioritized for long term success, hitherto a peripheral idea, the halting cash flows allowed for commitment to developing management. Ruiz-Salmón et al. (2021) on the other hand discussed how the loss of employment and demand during covid harmed the future of the industry. These kinds of shocks explain why doppelgängers and synthetic control specifically have been important to studying Brexit, as they allow to control for these large changes and shocks that countries share.

Kemp, Froese & Pauly (2020) discussed recoveries of fish stocks (i.e., fish available for harvest in the ocean) which is in line with Munro & Scott (1985). The overlap between the papers is in ecosystem regeneration, something which the former attributed to Covid reducing fishing harvests. As such, there is potential to generate increased profits given better regulation and reform. Indeed, this notion should not be dismissed as fishing has not been disturbed this much since the times of the second world war. Sustainability is important, and could account for government investment, however for this thesis, a focus on businesses means that this factor will not play as strong of a role. Previous research has described the issue of resource scarcity leading to market failures for UK fisheries, so one should assume that following covid-19 the industry would boom. For this reason, a model on industry specific metrics on profitability and output will be tested in this thesis.

Given the findings of the above papers, **Hypothesis 2: "**There is a negative effect of Brexit on British fishery recovery from negative shocks, following Brexit**"** is formulated. The failures of the policies related to Brexit on the direct performance are one point, however, a country might choose to harm its efficiency to achieve a more stable market. This hypothesis argues that the opposite would be true, as distancing from the EU means that the UK has a smaller amount of relief funds and lesser access to neighbouring markets which makes the industry more vulnerable to shocks like Covid. An important finding from the literature is how specific methods like synthetic control, allow to account for these confounders.

Data

The object of study in this thesis is in the performance metrics of Fisheries and Aquaculture. Several transformations must be done to study the relationships studied in hypothesis 1 and 2. Performance can be studied by profit margin which is represented by the letter (ρ) with $\rho = \frac{revenue-expense}{revenue}$ and further, by the numerator of this function, the net income as they provide relative differences between observations. Both metrics will be studied as they indicate the profitability of incoming revenues and the degree of competitive advantage in the latter counterfactual analysis. Another factor that represents productivity, is in asset turnover: a metric of revenue per unit of owned material, it can be seen as the contribution per value and is discussed in depth later in this section.

For the data process to be established, some core assumptions must be developed. Firstly, it is assumed that fisheries have little difference in the species that they harvest, as different fish are likely to be more profitable by weight. The reason for this assumption is because the data on individual fishery harvest diversity is unavailable, however a minimum size was chosen for fisheries which is likely to eliminate outlier micro fisheries focused on single species. Secondly, all values are transformed into Euros for the UK, controlling for year-to-year inflation (i) and real exchange rate (e) per year (t) through the formulation $P_{£} = e_t(1 + i)p$. Such an approach works more effectively than using net present values with discount rate due to the volatility of the past two years of Covid (Koç, 2021). Since three of the country's observations are already in Euros, the transformation is performed on Norway and the UK.

The data will be studied in panel form, which means that all yearly metrics are changed to show progress over time, for a more accurate change from regulation and policy. This is relevant to understand that year end data has been taken for each year, then grouped together to represent change over time. Elaborating on this point further in the databases section, the most reliable and complete data was available from the years 2013 to 2021, to compromise validity and size for national representativeness. Lastly for the specific choices: the five countries used to compare to the UK are Norway, Italy, France, Spain, and the Netherlands. This is because these are the largest producers in Europe which compete within the same waters and are all part of the EU (European Environment Agency. 2015).

Databases

The Food and Agriculture Organisation of the United Nations (FAO) is the foremost source on government and country data in the forestry, agriculture, and fishing industries. The FAO collects comprehensive environmental, business, and sustainability data for all UN countries, which allows to both compare scale as well as efficiency and make up of individual countries performance. The FAO is nevertheless slower then would be needed for this paper with publishing data due to the scale of their operation. Due to this, the choice was used to compare findings to the patterns that they found previously on gross national trends.

The database Orbis stores individual company statistics for hundreds of millions of companies around the world, spanning from small producers to industry dominating giants. The database standardises values between countries to account for differences in reporting, enabling a view of international companies' performance relative to one another. This allows to compare the UK to EU data, and it also allows to scale up the amount of data points to benefit from the law of large numbers in a more aggregate study. Important to any studies of Brexit and changes over time is a long period, as it smooths individual shocks that countries suffer, which as previously mentioned is 9 years. Such a period is shorter than optimal for synthetic control; however, it was chosen to balance representativeness with suitability as it matches previous research seen in Papyrakis, Pellegrini, & Tasciotti (2022).

To answer the research question, the data must be representative of national performance, which can be an issue when using Orbis. For this data to be representative, both the industry and the database must be considered. When looking at the industry, it is further discussed in the relevant variables section, how the classical approach of using small to medium (SME) sized firms is not effective as small fisheries are mostly comprised of seasonal and part time businesses. Such businesses would react differently to regulatory changes, as their owners and employees are not dependent on the fishery as a primary source of income (Ben-Hasan, Walters & Sumaila, 2019). The issues of using larger firms together with smaller ones, leads to loss of representativeness as discussed by Kalemli-Özcan et al.

(2022). Considering for the small size of the fishing industry, this issue is not as drastic as would usually be expected.

From Orbis 3138 companies were retrieved, which given the 9 years would optimistically provide 28242 observations, a number that was reduced following filtering. This is a very large pool of data, which has numerous benefits, although it introduces some cohesive issues. A high quantity of observations means that extreme outliers become minimized which greatly benefits the accuracy of the findings. On the other hand, there is room for error if the specific accounting standards of a given company are not standardized appropriately to match each other. As will be explained later, this was the example with the financing metric, debt to equity. In the kingdom of the Netherlands, there are specific rules for certain companies that allow for leverage to be signified by an equity or debt value instead of the ratio, which Orbis does not filter out (Kamer van Koophandel, 2022). To introduce a factor of capacity, fleet tonnage was retrieved from the European Commission (2022) to gauge the potential of each countries harvest size.

For the research, a period from 2013 was chosen to appease the differences between what data sources can provide. The earliest financially complete data available in Orbis, dates to 2013. This data is crucial to effectively study how fisheries operate and whether the assumptions made for the methods should be maintained. Potential metrics that were countered earlier in this report like sustainability and species composition would be subject to high error if they were merged in, and it would not be possible to determine individual company harvest from the national FAO data. The same data must be used for industry metrics, as then the country comparison can be elucidated by proof of specific relationships or mechanisms within the population studied. This choice narrows down the focus, hence it is assumed from this point onwards that all findings refer to the fisheries that make their accountancy available to financial databases such as Orbis. This statement applies to both the industry analysis and the study of UK performance following Brexit.

Relevant Variables

The primary goal of research is to organize a relevant dataset and clean off irrelevant and outlier data. For fisheries, in many countries' activity can be full time or seasonal, hence the focus for this paper will be on full time fisheries that represent the industry. Instead of using a revenue categorization, a choice was made to use industry classification as provided by the database Orbis. The companies used are medium, large, and very large within the Orbis database. Small fisheries are filtered out of the dataset as they mostly represent inactive businesses which have low economic contribution, and the owners of which depend on fishing for supplementary income (Ben-Hasan, Walters & Sumaila, 2019). The effects of Brexit are studied on a competitive advantage and efficiency point of view; hence it is likely that part time fisheries, or small fisheries would account for businesses that do not maximize profits to regulation.

For the primary method of processing, in the linear regression there are the several important variables. Foremost, net income, a metric of cost minus revenue is the dependent variable for the regression, for which earnings before interest and tax (EBIT) is used. The advantage of EBIT is that tax is omitted as well as financial trust and interest rates, which gives a more direct metric of how well the company performed without considering country tax laws, benefits, or priorities. Such a dependent variable should purely reflect the profits of production, which in terms reflects productivity. Efficiency can be understood from the further counterfactual analysis that compares the profitability in two scenarios. For a simple linear regression, the independent variable is ambiguous, considering that the purpose of the study will be the effect of policy change. The choice for a linear function comes from the research of Munro & Scott (1985) who assumed high elasticity of demand, which is false in the short run. Elasticity is around 0.5, however when studying longer periods of time it increases drastically to becoming highly elastic (Andersen, Roll, & Veterås, 2008). Since this Thesis looks at long run data, the linearity assumption will be held where given high elasticity of demand for fish, production follows a linear trend.

The controls collected for the regression (of which any could be seen as the independent variable) are employees, net assets, debt to equity ratio, and market capitalization. For effective controls, one should either test the assumption of random effects or fixed effects, which means testing the correlation of controls. To avoid pseudoreplication within the model, a Hausman test was performed to determine whether a random or fixed effects approach would be suitable. The test rejected the null hypothesis for most of the regression models and comparing the chi^2 values the decision was made to use constant fixed effects, over a high-definition fixed effect model. Important for the control variables analysed is that the net assets variable was strongly correlated with employees at 0.86, which is logical considering that larger operations need more employees. Hence, a new variable was generated, for individual company competence. This variable is $asset\ turnover = \frac{revenue}{net\ assets}$, and it will allow to analyse the policy effects better between companies as their individual competency in using materials and plants property and equipment (PPE) is controlled. Scale, competency, and company financing are all controlled for in the research.

An issue that arises with further processing is that now there are three variables that are ratios or percentages. The usual approach is to take a log of the variables, which would be log(turnover), log(D/E), and log(profit margin). The caveat of this approach is that the variable of interest should only have positive values, which is not true for all three of these controls. The interpretation of the controls would be somewhat limited if the logarithmic transformation is omitted, hence it was still processed using the STATA generate commands on the information. For data that uses logarithmic variables, can only be created for firms with positive revenues and a positive Debt to Equity ratio, some data is lost in the transformation. With turnover, the logarithmic function only eliminates 765 observations from its original 11,774, while profit margin loses 2,835 from 11,015 and most drastically leverage goes from 14,552 to only 7,193 observations after taking the log. With over half of Debt-to-Equity data being in the negative, an error with the data is visible, hence using the logarithmic transformation provides better data, however it sacrifices validity and omits many companies which can harm the national representativeness.

Important to mention for synthetic control, is the use of European Commission data for tonnage capacity of fleets in Kilotons. It is superior to water access, as in practice it is non-enforceable, making it a purely political move contrary to the actual capacity of a fleet which is a real limitation. To further reiterate the obscurity of water rights, in the past the UK has lost a militarized international dispute against a much smaller Iceland known as the Cod wars as enforcement of these boundaries was physically not feasible (Frost, 2021). Tonnage capacity of the fleet is a good alternative to water access as it describes exactly how endowed a countries fishing industry is in terms of potential harvest. Tonnage capacity can control for some degree of benefits from clustering in larger industries, and fits with the established relationship in fishing, where supply can only be observed through real harvest.

Descriptive Statistics

The company data collected can be seen in table 1, several adjustments were performed on the information available below. There are discrepancies and more obvious issues that appear when a large dataset containing differently sized diverse companies relating to the accounting formats used, and information disclosure. For these reasons, one can note the discrepancies in observations between all variables, which was already existent before the data was filtered. Debt to equity ratios seemed to differ starkly, especially with the

Netherlands where values in the 1000's in both the negative and positive direction were apparent. The likely explanation for this pattern is in differing requirements for differently sized companies, like in the case for Dutch 'medium sized' companies, having 6 circumstances in which either using another European format or a non-European business structure is allowed for disclosing annual reports (Kamer van Koophandel, 2022). Due to this, a liberal minimum and maximum was set of -10 to 10, eliminating 1,898 observations. Following this, two other variables had to be adjusted within the dataset.

The two variables that were filtered for the sake of eliminating noise, were net asset and employee values. For both variables, observations equal to zero and lower were eliminated from the dataset. Hence, 2,016 observations were eliminated for net asset, and 1,537 for employees. In terms of the former, it is simply not possible to have an operating company with zero employees. The argument for net assets goes beyond the feasibility question, as it is possible for a company to have liquidated all its assets. However, such cases would represent companies in circumstances too specific to apply to the scope of this research, hence these were the grounds for eliminating those observations. The software for processing this data: STATA, accounts for missing observations so Market Cap can be kept, however due to its very low representativeness, it was not used further in the report.

Table 1: *Descriptive statistics for the entire sample of companies retrieved from ORBIS*

Variable	Observations	Mean	Min	Max
Revenue	11774	21438.07 (169987.50)	-1370	4651886
EBIT	11867	3275.63 (26050.73)	-258733	838369
Employees	9014	46.51 (453.59)	1	14866
Net Assets	14552	28819.52 (240019.90)	1	7567053
Market Cap	48	2828194 (3376016)	28677	1.2×10^7
Leverage (D/E)	14552	0.45 (2.09)	-10	10
Profit Margin	11015	0.95 (42.09)	-600	3275

Notes: The descriptive values, showing EBIT, Revenue, Market Cap and Net Assets in 1000's of Euros shows some of the previously mentioned adjustments. The minima for Employee and Net Assets are set at 1, and leverage has been adjusted by deleting all observations with a ratio greater to 10 or lower then -10.

In **table 1** above, the filtered data is described for the companies collected. What draws immediate attention is the high standard deviations for all results, which is to be expected considering these statistics are for 6 different countries with very differently sized firms. The observation count is also quite heterogenous, and most observations are counted in the tens of thousands. The exception to this is for the variable market capitalization, in fact the companies with market capitalization data are only in Norway, and they are the largest ones in the country. For this reason, data available on market capitalization has little use, and was left out during further processing. The filtering is also quite evident with the leverage minimum and maximum values, as well as the minimum values for net assets and employees.

For the individual countries, the data was also summarized, seen in Appendix 1. The relevant points of interest are in the between group (country) observations, the Netherlands has the least with 801 observations of companies, while Norway tops the count at 5832. The UK has 2181 net observations, which is around the amount that Italy and Spain have, although the UK has the highest mean revenue of any country on the list. This fact can be attributed to how many companies submit their revenue data to ORBIS. Indeed, this will be an issue as in certain countries data seems to be incomplete, presenting a potential source of bias. To consider this, several regression models were developed, which are further elaborated in the next section.

Methodology

Baseline regression model

The data studied as a time series in panel form allows for the use of simple linear regression. As a more complex method is used for the counterfactual, and the data is built from different sources, the standard form of $y = \beta_0 + x\beta_1 \ldots + \epsilon$ provides strong enough justification for relevant effects and metrics that could influence the analysis. The fully expanded regression is the following: $EBIT = \beta_0 + L\beta_1 + \tau\beta_2 + \partial\beta_3 + \varepsilon$ where L is labour (employees), τ is asset turnover, and ∂ is the debt-to-equity ratio. The regression is only the initial process of finding the effects of production, size, or division of capital on profits. To connect this further with the specific regression performed, the fixed effect regression accounts for the fact that specific geographic and time related effects impact all of the variables within the panel studied, hence the constant serves mostly to control for this providing more accurate coefficients. The descriptive data presented underlying patterns and observations within; however, additional one-sided ANOVA testing will allow to find the divergence of means between countries.

Simple linear regression tracks the relationship between variables, fitting them into a hypothetical linear function as seen previously. The reason for not including profit margins is twofold. It would be possible to perform a linear regression on a percentage metric, however a logarithm allows for the interpretation to be linear. This is possible for a debt-to-equity ratio as negative values are very uncommon, so the omission only excludes around a hundred observations. With profit margins it is quite common that the net income for the year is negative, hence it would diminish the value of the data to use net income or to regress by it. The goal of the regression is to establish what are the effects of individual observable characteristics or results on the outcome variable of net income.

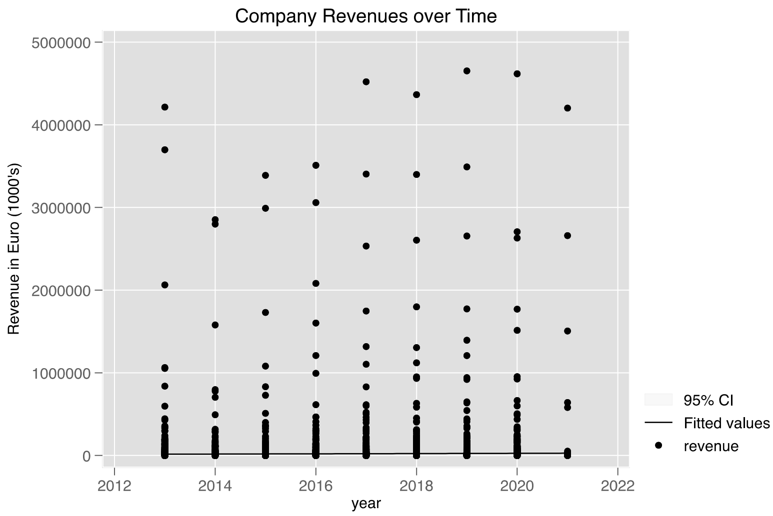


Figure 1.1: *Scatter plot of revenues in the dataset over time measured in thousands of Euros.*

Additionally, one-sided ANOVA tests will be performed as they can effectively show the individual scores for country categories. ANOVA tests for differences in means between more than 2 groups, assuming no extreme outliers, independent observations, and normal distribution of the dependent variable. While there are 2 other assumptions, effectively all are met, except for the normal distribution, as the EBIT is skewed right, within the sample. Accounting for the small size of the industry, and the filtering, this skewedness is towards what would classify as SME’s, increasing the national representativeness of the findings. Seen in **Figure 1.1**, the data is very skewed to high revenue companies, the trend seems visually at 0 but this observation is purely visual, which one can see in the uniform group of extremely large companies over all years. This makes the normal distribution assumption false, but the other two are valid. Extreme outliers were filtered out, and observations can be assumed to be independent as a company observation would not influence Orbis to include another. With these points considered, ANOVA is the best method of testing for equality of means and determining which countries could differ enough to be further regressed or studied on an individual level.

Once the general trends are established, a secondary regression is performed with logarithmic parameters. This is supplementary, as the results found will only have implications on revenue turning companies with positive Debt to Equity ratios. Any differences in magnitudes, or especially direction might give precedent to the size (dis)advantages that companies might have within the industry. The formula for this regression would be $EBIT = \beta_0 + L\beta_1 + \log{(\tau)}\beta_2 + \log(\partial)\,\beta_3 + \log(\pi)\,\beta_3 + \varepsilon$.

Synthetic Control

The method of synthetic control is one of the newer methodologies developed in the field of econometric impact evaluation. This method will help answer the research question by creating a doppelgänger UK using observable characteristics of similar economies. The method weighs countries outcomes and factors to closest resemble the United Kingdom in the times before intervention, which in this case is 2020. This is the exact method of Papyrakis, Pellegrini, & Tasciotti (2020) and like that of Springford (2022), however due to the fishery focus, the intervention period is initially set at 2020 (Edington, 2020). This intervention period was chosen because it is the de facto beginning of legislative changes for the UK, with customs and border controls on labour and goods. The method assumes that the intervention, in this case the policy change, happens only to the group studied through counterfactual. There exists a degree of trade between all the countries studied, however the relatively low level of spill over effects on the EU compared to those on the UK was shown in Thissen et al. (2020). The other countries studied will only have a portion of the effect of Brexit, while the degree of multiplier effects and policy changes are most directly relating to UK businesses.

It is possible to adjust the synthetic control function to best describe the research of this report with the function: $\Delta EBIT_{Brexit} = \min\,(EBIT_{UK} - \sum_{n-1}^{m} EBIT_m W)^2$. The function is derived from the previous research on unemployment by Papyrakis, Pellegrini & Tasciotti (2022) adapting it to profitability of fisheries. EBIT has already been defined, m reflects the number of countries used, and W is the weight assigned to a specific country. The weight is constructed via algorithm by the software STATA, which individually compares the country outcomes compensating for predicted errors and optimizes the best combination of groups. Synthetic control balances the approaches of difference-in-difference methods and matching; hence its assumptions are quite different.

Instead of a common overlap like with matchmaking, the process requires that the data is strongly balanced, which means that observation counts should be similar and corresponding between observations. The other assumptions are that the control group does not have idiosyncratic shocks and is not subject to spill over effects. Idiosyncratic shocks in the period 2013 to 2020 were infrequent until Covid (Alam et al., 2022), where the effect was detrimental for fisheries globally, however, the synthetic control method accounts for time invariant confounders. The strongest motivation for using this method is that it relies on several units for control which are selected arithmetically. The method was designed for studying aggregate level effects on small groups of large units, which is why it is suitable for a small group of country averages (van Kippersluis, 2022).

Results

Regression analysis for company data

The beginning of the regression analysis begins with a check for all the research relevant control variables. Namely as seen in **table 2.1** the available controls are performed on correlation with one another. It is thus further justified why the net asset variable is substituted for asset turnover. One can see that there is a strong correlation between net assets and employees, but it is likely a confounder as more net assets increases income leading to employment. Therefore, the variable must be removed to avoid muddling the coefficients/causal effects.

***Table 2.1**: Correlations between control variables for the first regression*

Variables	Net Asset	Asset Turnover	Employees	Debt-to-Equity
Net Asset	1.00	-0.03	0.86	-0.01
Asset Turnover	-0.03	1.00	-0.01	0.02
Employees	0.86	-0.01	1.00	-0.01
Debt-to-Equity	-0.01	0.02	-0.01	1.00

Having evaluated the best combination of variables, the following set of models was established in **table 2.2**. There are 5 models, the first four pertaining to the variables from the general regression while the last one accounts for profit margins, leverage, and turnover in their log form. The results are significant across the board, which means that the effect of variables chosen are unlikely to be subject to chance. The rho values differed between models, but were generally quite low, which is to be expected when one looks at the descriptive statistics and further here, with the standard deviations. The highest rho was for model 5 which means that for this model, 61% of the variance in fixed effects between companies is explained by the model.

Table 2.2*: Five simple linear regression models on EBIT using controls, all outcome in thousands of euros.*

EBIT (€1000)	Model 1	Model 2	Model 3	Model 4	Model 5
Employees	42.68***		42.69***	42.68 ***	29.70***
	(0.863)		(5.152)	(5.150)	(2.629)
log(asset turnover)					738.6 *
					(440.6)
log(debt-to-equity)					-289.7*
					(207.5)
log(profit margin)					1,645***
					(404.3)
Asset Turnover		-27.14**	-84.37**	-84.83**	
		(12.99)	(33.97)	(34.41)	
DE				-85.70**	
				(37.92)	
Constant	7,041***	1,523***	1,542***	1,612***	8,453***
	(352.9)	(447.5)	(363.5)	(373.1)	(1,546)
Observations	7,980	11,771	7,844	7,844	3,112
Rho	0.437	0.554	0.435	0.435	0.609

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Overall, the regressions provide significant results, with useful information on how labour, productivity, and financing affect net income in the fishing industry. Most of the results are highly significant and indicate that employment in all cases tends to lead to higher profits, counterintuitively this is likely to be subject to reverse causality. A quick regression was run to confirm that the relationship is positive in the opposite direction, and it was: with additional profits contributing to increased labour. Most enigmatically, asset turnover seemed to reduce the profits of a company. This could indicate that assets have a diminishing effect on profits, however that is ignoring the issue of asset turnover being regressed linearly even though the value is a ratio. The logarithmic formulation of this function reduces the available observations to 3,112 which is a lot of data, but the findings only apply to companies with positive D/E ratios and revenues. Nevertheless model 5 gives elaborates on this conundrum.

Model 5 analyses companies that are turning profit and holding regular debt to equity ratios. These assumptions are not as demanding as might be expected when one comes to consider the source. The companies that were removed due to having a negative value for the pre-logarithmically processed variables could have had negative values if they use some fringe accounting techniques, but usually neither of the two values should be negative. Because of this, the model can be considered for the following: 738.6 is the coefficient for log(turnover) or as previously mentioned logτ. If one is to isolate the outcome and this variable from the function previously expanded, the formula becomes $EBIT = \beta log\tau = 738.6 log\tau$, with the log base e which was used in Stata. One can extrapolate what a 1% increase in asset turnover brings to the company with the function $1068 \times \ln(1.01) = 7.35$. The effect of asset turnover, and individual productivity is significantly positive, as a 1% increase in productivity of assets leads to 7,350 euros of additional pre-tax income on average. Lastly, it would be relevant to mention, that in this case including profit margin in the function is not false it just accounts for the degree of cost burden taken by the firms.

Finally, to compare means between countries one way ANOVA was used, seen in **Table 2.3**. This test simply provides more elaboration on how the data set is distributed and the differences in means between categories. Initial processing proved that variances were very different between samples through a Bartlett test of equal variances seen in Appendix 2. Due to this a non-parametric Kruskal-Wallis one-way ANOVA test for equality of means was performed. This impossible as the random data is continuous, sufficiently large, and similarly shaped. It is clear from the test, that countries differ substantially between groups, justifying the choice of the next method.

Table 2.3: *Kruskal-Wallis test on equality of means with p-values separated*

Variable	$Chi^2(5)$	P-value	$Chi^2(5)$ with Ties	P-value
Revenue	956.60	0.00	956.86	0.00
EBIT	1356.07	0.00	1356.08	0.00
Employees	381.55	0.00	382.03	0.00
Net Asset	2767.13	0.00	2767.13	0.00
Debt to Equity	983.67	0.00	983.76	0.00
Profit Margin	1322.09	0.00	1322.10	0.00
Log Margin	1683.73	0.00	1683.73	0.00
Log Debt to Equity				
Asset Turnover	2807.00	0.00	2807.74	0.00

UK performance

The synthetic control had to be established on a set of observable characteristics that are parameters for weighing a doppelgänger UK. Considering the large set of refined variables, and a timespan which is sufficient albeit slightly limiting for the method, this step was crucial. The variables used were employees, log(asset turnover), tonnagecapacity and log(debt-to-equity) on EBIT, or earnings before interest and taxes. The results seem to indicate a very drastic difference that is likely due to an error with the selected groups. Seen in **figure 3.1**, the difference is very drastic following 2020. The synthetic control has a p-value of 0.4, which means that there is a 40% chance this effect is not a result of Brexit, rather that it is random.

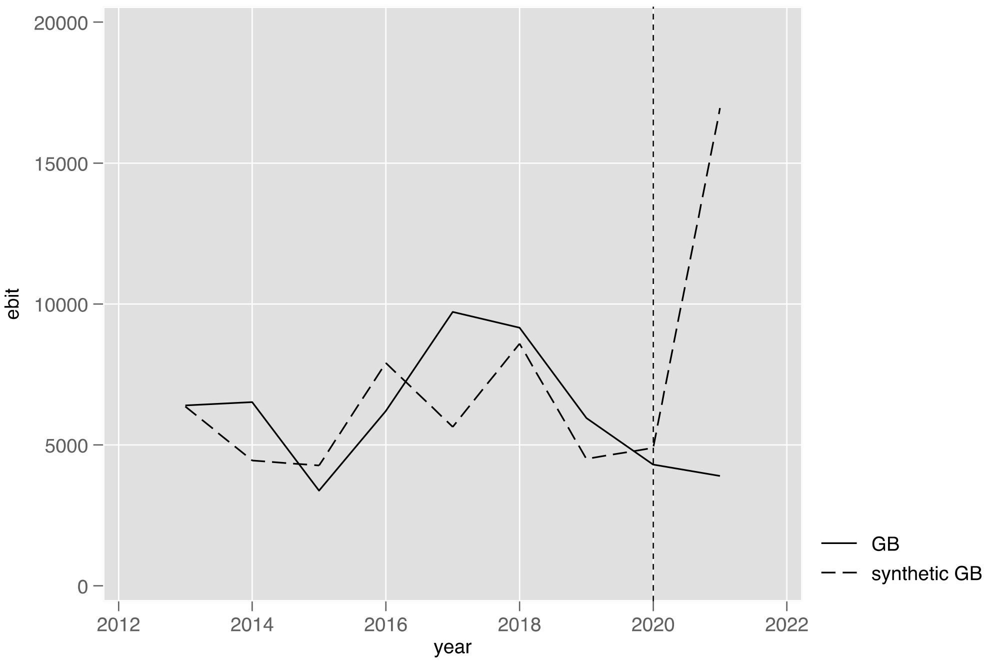


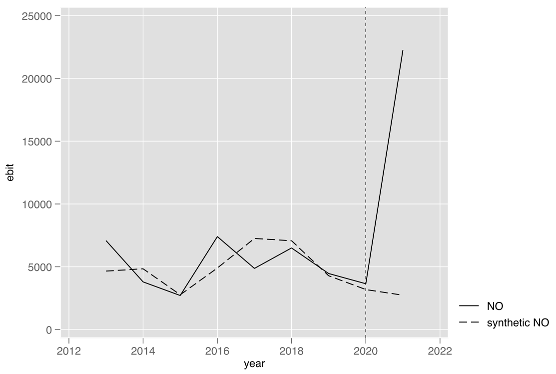
Figure 3.1: *The synthetic control counterfactual of income for UK fisheries following Brexit.*

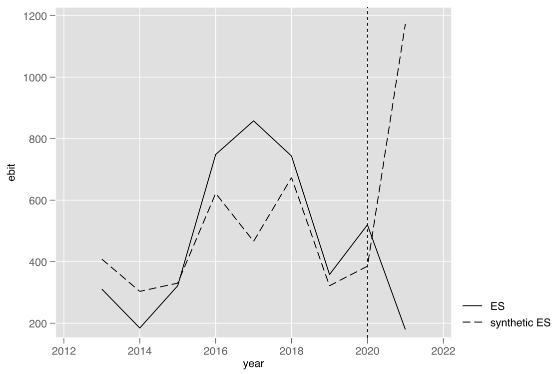
Perhaps to better understand how the counterfactual differed so much from its actual results, one can look at the weights assigned table in **table 3.1**. It is clear in this table that the weights that there was an issue with matching by means. The means of the Netherlands and Norway are the lowest and highest respectively, which can be seen in Appendix 1. Objectively, it would be most likely that Spain would weigh at least to some extent on the British counterfactual. Nevertheless, the results are not entirely false. If one is to consider that the British market has been following the same trends as the Norwegian, but much further scaled down.

Table 3.1*: Weights assigned by STATA*

Country	Weight Assigned
Spain	0.000
Norway	0.751
Italy	0.142
France	0.000
Netherlands	0.107

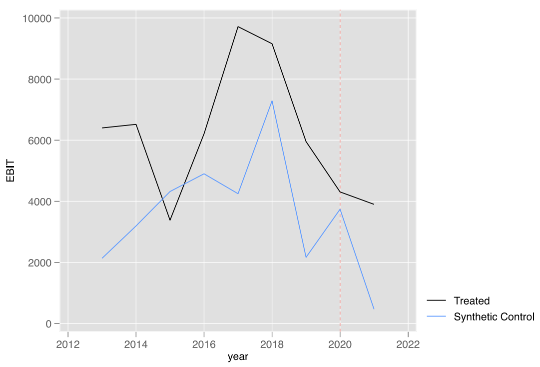
Robustness checks for the method were performed by placebo testing Brexit with countries that did not undergo the Brexit referendum. The synthetic control was not effective, as all data deviates before and after treatment, although interestingly the jump seen in Britain's synthetic control was mimicked by Spain, unlike the other countries which seem to have more conservative synthetic controls, seen in Appendix 3. The one country which seems to have this large increase in net income is Norway, a country that weighed very heavily for both the UK and Spain. One can see the graphs for Norway and Spain in **Figures 3.2 and 3.3**, with the synthetic control of the latter also comprising most of its weight of Italy and Norway.

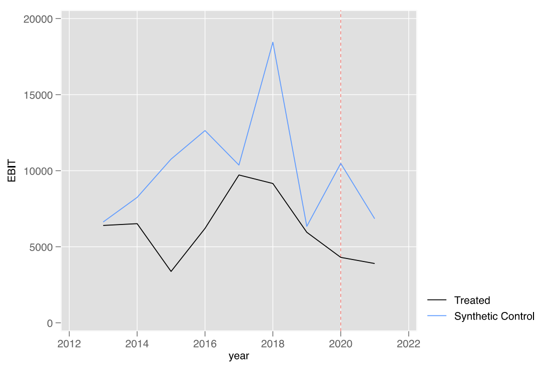




Figures 3.2 &3.3: *Placebo Brexit with Norway(left) and Spain(right) with EBIT in Euro*

A choice was made to eliminate Italy and Norway from the analysis to assess how the different weight distribution would affect synthetic controls. These can be seen in **Figures 3.4** and **3.5** where Norway and Italy have been eliminated in the study of the UK. This approach is not deterministic; however, one can establish issues with data and significant results, seen in the p-values of 0.10 and 0.05 respectively. The direction of the synthetic control is opposite to the previous findings and shows the UK fisheries performing better than the counterfactual by €3,517 euros and underperforming by €3,046 of profit on average respectively. What is clear visually is that the slopes are visually similar between the synthetic controls, although the overall level of performance differs.





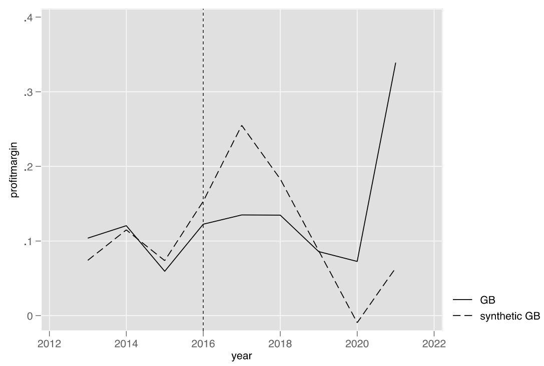
Figures 3.4 and 3.5*: Synthetic control on EBIT in the UK omitting Norway and Italy respectively. Values are expressed in euros of pre-tax income for the average UK fishery.*

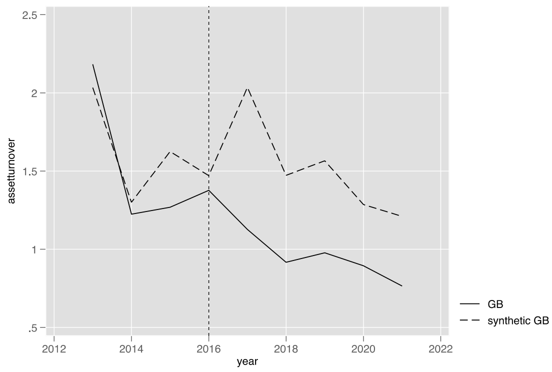
The disparity of results between the initial model and the following two is quite strong. This is especially true, when one considers how similar the synthetic controls in **Figures 3.4 and 3.5** are. With a lower p-value the algorithm is more confident of these post treatment effects being not subject to chance, which is more likely to be true. Given the presence of the pandemic, it is much more sensible that having seen the downturn in specific metrics during 2020 that the synthetic control would predict that fisheries would perform poorly. Seen in **Table 3.2** the change in weights for these controls is a core metric, the removal of Norway lead to the Netherlands becoming the closest comparison by weight, or the removal of Italy distributing some of the weight from Norway to other countries.

Table 3.2: weights assigned to synthetic controls omitting specific countries.

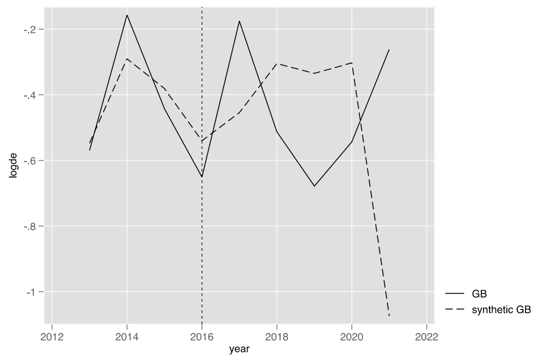
Synthetic control without Norway		Synthetic control without Italy		Synthetic control without Netherlands	
Country	Weight	Country	Weight	Country	Weight
Spain	0.000	Spain	0.044	Spain	0.000
France	0.619	France	0.222	France	0.000
Italy	0.177	Netherlands	0.480	Italy	0.195
Netherlands	0.203	Norway	0.254	Norway	0.885

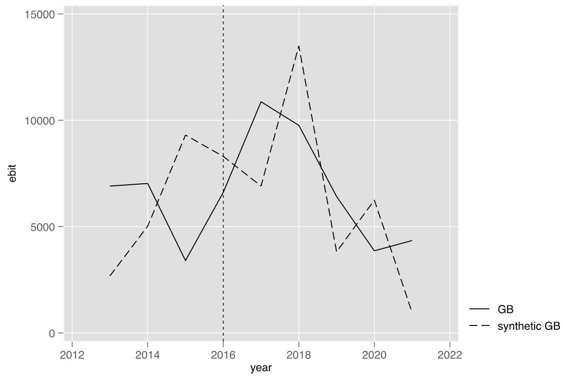
What is evident when referencing the descriptive statistics, is that disproportionately high values for EBIT are seen across countries, hence referencing the discussion of Kalemli-Özcan et al. (2022) on Orbis, the issue is mitigated by limiting the size of companies considered. This was done using the golden rule for outliers, where all datapoints with EBIT over 150% larger than the interquartile range were eliminated, thereby removing 1721 observations. The size of this number further shows how profound the effects of outliers could have been. This could help the likes of Norway become more representative, as this country has the largest firms, but also supports the largest population. For this refined synthetic control, initially the same issue was found on pre-treatment data, with ample delayed effects, hence the date was moved back to 2016 as what the method has proved thus far, is that even with the real changes occurring 4 years later, the announcement date has influenced fishery incomes. To further understand all the effects of Brexit, 4 outcome variables were studied: log of debt to equity, profit margin, asset turnover, and once more EBIT.





Figures 3.6 & 3.7: *Profit margin(left) and asset turnover(right) studied at the brexit announcement date of 2016.*





Figures 3.7 & 3.8: *Log of debt to equity(left) and EBIT in euro(right) studied at the Brexit announcement date of 2016.*

Moving back the intervention date is a usual robustness check, as seen in the original synthetic control study of Abadie, Diamond, & Heinmueller (2015). Here however, it also delivers some explanatory power for the white noise in the first half of this subsection, as announcement effects. The p-values, graphically seen in Appendix 4, are much lower for this data and the controls are substantially more believable. In the case of two outcomes: debt to equity and asset turnover, the p-values are almost all highly significant. Inferior performance is also seen with profit margin, in the significant post treatment dates of 2017 and 2019, this finding also has a very low root mean square predicted error (RMSE) of only 0.019 which indicates that the data strongly fit the synthetic control model. Subjectively, the asset turnover data has the most explanatory power as this is a productivity measure adjusted to the size of companies, with significant results and the second lowest RMSE of 0.227.

This significant measure does indicate that the UK has been underperforming relative to a situation where it would not have left the EU, and in 2020 the average British company would have a turnover of 1.283 instead of their real value of 0.894. Since the real regulation on border crossing and customs went into effect following 2020, this could be seen as a response in changing expectations and business operation. The debt-to-equity ratio provides some further information, as with $\partial = e^{\log(de)}$ debt-to-equity ratios were lower between 2018 and 2020, showing a reluctance to take on debt. It is once more the case that UK efficiency would be more susceptible to shocks, with greater year to year changes in asset turnover and profit margin (except for the insignificant result for 2021 in the latter).

Conclusion and Discussion

This thesis has aimed to answer the question "To what extent has Brexit impacted the profitability and efficiency of British Fisheries?". The research delved into literature, which indicated in the most part, loss of competitive advantage, and reductions in productivity. The research delved into the measures of profitability for fisheries, with a focus on the direct location and business effectiveness of fisheries. Summary statistics confirmed the UK's position as a large, but not entirely dominant actor within the industry. Using linear regression, the primary control variables were discovered, and a suitable outcome was set of earnings before interest and tax (EBIT). The synthetic control counterfactual was performed to test the changes in performance for UK fisheries, and evidence was found that would indicate the UK gaining some degree of stability, but overall performing worse.

Hypotheses and connection to previous literature

The literature discussed previously has indicated quite strongly that the UK will lose out on the conditions that they would choose to leave the EU. An analysis of labour markets had indicated that the actual outcome has been rather indifferent of these predictions, and it followed in line with the expectations for the UK (Papyrakis, Pellegrini, & Tasciotti, 2022). The data found through counterfactual analysis in this report indicated otherwise, however due to the high probability of invalidity the findings are not definitive. If one was to assume the previous findings on unemployment were true, and costs for employment have remained stable, this could counter the findings on fisheries. However, amongst the most established of publications, both the Springford (2022), and Thissen et al., (2020) papers were describing and forecasting negative performance.

The more directly relevant findings, in the regression of financial data on companies can provide some insight into the assumptions made in this paper from previous literature. Kierath (2018) discussed the growth of aquaculture, and indeed the industry seems to be far from decline when looking at the production trends between 2013 and 2021 from **Figure 1.1**. Further, Scott & Munro (1985) developed the concept of a finite structure to fishing, and the quantity of biomass. Indeed, it could be observed that a specific capacity is in balance, as fish production has been stable when summing the countries studied. There are also enough grounds to state that fishing economies do not just differ in size, but productivity and financing as seen through Kruskal-Wallis testing on equality of means.

As for the Policy implications, it seems that the findings of Whitmarsh & Young (1985) have faltered. The scholars were adamant on competitive measures and business performance being irrelevant in fishing since lack of regulation and enforcement out shadowed labor productivity, destabilizing competition. If these findings held true, it would be apparent in the regression, however, there were significant indicators that labor and productivity have a positive effect on profitability. The hiring of an additional employee on average contributed 29,700 euros of profits, while a 1% increase in asset utilization for revenue constituted an average increase by 738.6 euros for companies in the 6 countries studied. The regulation argument could still hold ground; however, it is quite evident that fisheries are still benefiting from scale and competency. This is significant, as clustering is commonplace for smaller fisheries (Khakzad & Griffith, 2016), while it is possible that these benefits could be harnessed much more efficiently by larger producers.

Returning to the core focus of the paper, synthetic control differed depending on research design. It was initially found that using a complete model with Norway, Italy, Netherlands, France, and Spain, that the UK underperformed drastically. The magnitude of this underperformance could not be quantified scientifically, as it was clear that the estimated shortfall was too severe. Backdating the Brexit referendum, not to 2020 but to 2016, gave a more sober picture of the referendum that indicated that only for 2017 and 2019 UK fisheries performed better than their synthetic control. Further, introducing changes to the data that increase the national representativeness of the database Orbis, lead to many harmful outliers being omitted.This was found by initially removing specific countries, which indicated this bias further. With Norway and Italy were removed specifically, for the size of the economy, and the incompleteness of specific data respectively, results indicated a similar trend, at differing magnitudes.

When the study was performed with keeping these countries but removing the outliers, significant synthetic controls were produced. The important thing to keep in mind, is that the period in these values was only for four years before the intervention, hence even significant results should be considered with caution. If one is to assume a Brexit date of 2016, there is significant evidence that productivity measured in asset turnover has diminished following the referendum. There is some evidence that profit margins have also been lower, and interestingly that British fisheries have taken on less debt. The first two of these findings can help answer hypothesis 1 where there is evidence that Brexit has decreased efficiency and profitability. The extend for the former can be determined for 2020 where the average UK fishery had a lower asset turnover by 0.389. For profitability, the evidence is not strong enough, as the significance of the synthetic control for profit margins is incongruent.

For Hypothesis 2, in all significant profitability and efficiency metrics, changes have been more stable relative to the counterfactual. This relationship is not very strong, and the outcome of the research was not precisely enough to effectively determine the extent of this, however there is visual proof to reject the hypothesis. The higher number of peaks and troughs in statistically significant counterfactuals, compared to the real data indicates that metrics for UK fisheries have been more stable following Brexit. The grounds for both answers have several issues that must be addressed such as moving intervention back in time to accommodate for the announcement effects discovered. Likewise for the data collected, despite having performed significant changes and alterations, needs further refinement to better answer both hypotheses.

Evaluation and future improvements

Both the contributions of this paper, as well as its limitations and improvements will be analysed to determine the value and purpose of the research. It has previously been described how clustering is evident in the fishing industry, and indeed there are inequalities with specific countries, as has been seen with the effect of Norway on synthetic controls in this paper. It should be kept in mind, that several assumptions were made, one of which was a linearity to production, which is most definitively false when one compares the degree of efficiency and profitability between 6 countries with prominent fishing industries. Another aspect to appreciate is that the paper has dealt with physical, post Brexit data the way that Springford (2020), or Papyrakis, Pellegrini, & Tasciotti (2022). This thesis looks at a niche industry, and experiments with aggregated data on different economies within the European region. The results do not dispel the effectiveness of synthetic control, rather they underline the importance of complete and precise data, with the possible necessary adjustments that make this method feasible.

The paper relied on ORBIS for most of the data, which is a useful database although it does present some shortcomings. The database had over 300,000 registered and active companies in its database for fishing alone, however many of these companies were too small, too large, or did not provide certain necessary financial data for processing. This was accommodated for in the filtering process, however, still there were at times thousands of observations that needed to be eliminated from the research, which influenced the external validity. Once this data was filtered, for the regression specifically a high degree of internal validity could be achieved in understanding how size, productivity or financing influenced earnings. An extension to improve this would be the ex-ante attempt that was made, of individually extracting data.

Countries publish their own reports on fisheries and aquaculture, however the process of filtering this data and accessing it is both time consuming and highly complex. The reason this approach to data collection was omitted was because many countries do not publish their reports until much later, and often keep certain information classified. If one was to perform this research at a much bigger scale, with the encouragement of the educational institution and funding, then country bureaus could be individually contacted for the relevant and complete information on their production, establishing an externally consistent sample.

There are several relevant metrics which could have improved the external validity and the internal validity of this paper. There was unfortunately minimal data on exact policy changes such as water access or capacity factors, like harvest composition. In the case of the former, water access and degree of enforcement could have controlled for the size of the potential fishing haul that a country can bring in. A substitute of fleet tonnage from the European Commission (2022) was used instead, but it does not account for how bountiful the waters are, and in term how much actual endowment a country has access to. Data is published on specific seas and fishing areas; hence a potential improvement would be developing a probability model using the ships that fleets are made up of and their point proximity to fishing waters to estimate how much each country caught from which area.

For possible extensions to the study, the works of Kemp, Froese & Pauly (2020) or Scott & Munro (1985) come to mind. The composition, method of harvest, and impact on ecology are now accepted as some of the best forward-looking metrics for fishery success in the long run (Ruiz-Salmón et al., 2021). This thesis did not include such metrics due to the present lack of congruent national level sustainability metrics that could correspond to financial data. Since the 80's the understanding of fisheries has improved, hence a model of net biomass or carnivorous species harvested could be a feasible improvement. The FAO publishes a breakdown of all species fished by tonnage around the world. This data is incredible useful; however, it is mainly published in a format for marine biologists and ecological studies. If one was to accurately connect the tonnage with ecosystem capacity and develop a model of replenishment which can connect the effect of one species being fished on the availability of others, then the capacity of supply could be established. Such a view into the survivability of fishing for a country, might provide a more informed estimate for future profitability. To support this trend with recent examples, the UK has introduced electronic camera monitoring of fish harvests, a breakthrough in sustainability that might put them ahead of their competition in years to come. (SeaScope Fisheries Research, 2017).

Lastly and most related to the economic theory of this paper, there is a need to establish direct and indirect effects. It is not extrapolative to assume that Brexit has had profound effects on agent behaviours, the announcement of leaving a political and economic union is likely to induce numerous effects. It is most likely for this reason why most research still uses the announcement date not the real date of Brexit as the intervention period in the study of Brexit. In this paper, such an approach was attempted, however a long enough pre-treatment period was unavailable for 2016.

Synthetic control both needs a sufficiently large period to accurately deduce a credible counterfactual, and it requires strongly balanced and relevant observable characteristics. Including a behavioural model on the way that investors, fishers, and fish consumers have reacted throughout the timeline of Brexit in terms of both business decisions and personal consumption could have smoothed the delays visible in most of the figures from the results section. This would mean that the method could be tested both on the commonly used 2016 date of announcement, or on the date of 2020 to establish what was the direct effect of Brexit.

Overall, the report gives an adequate look into how Fisheries operate, and the observable trends on the production of Fish in the United Kingdom. The thesis answered the research question, with British fisheries performing poorer in terms of productivity and profitability following the announcement of the Brexit referendum, although there seems to be less fluctuation in their business performance. Their competitive capability seems to be inferior to what it would have been in absence of Brexit. These patterns and cause effect relationships give an image of the current situation, hence if more research is done in the future using elevated econometric and economic techniques, then these findings could be further supported.

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Appendix

Appendix 1: Individual country descriptives

> country = NO

Variable	Obs	Mean	Std. dev.	Min	Max
ompanynam~t	0				
year	5,832	2016.74	2.223005	2013	2021
ountryiso~e	0				
astavaily~r	5,832	2020.048	.2855524	2016	2021
revenue	5,829	32637.61	236472	-186	4651886
EBIT	5,832	5832.519	36629.21	-258733	838369
employees	2,721	90.44873	819.7443	1	14866
netasset	5,832	57405.46	375370.3	1	7567053
mktcap	48	2828194	3376016	28677	1.20e+07
DE	5,832	.6589129	1.97994	-9.98	9.96
country	5,832	6	0	6	6
company	5,832	1588.794	897.8443	3	3110
rofitmargin	5,138	2.276692	61.02218	-600	3275
logDE	3,497	-.3330222	1.377305	-4.60517	2.298577
ogprofitm~n	4,054	-1.664998	1.467862	-8.89563	8.094073
ssetturno~r	5,829	.6127317	2.248327	-.0145719	140.5556
logturnover	5,134	-1.018787	1.385658	-9.567945	4.945603

-> country = NL

Variable	Obs	Mean	Std. dev.	Min	Max
companynam~t	0				
year	801	2016.78	2.304162	2013	2021
countryiso~e	0				
lastavaily~r	801	2020.092	.4836884	2015	2021
revenue	17	45253.29	62655.53	1	209338
EBIT	45	2870.311	13021.4	-7599	86569
employees	310	9.2	11.6904	1	54
netasset	801	12177.13	54714.53	4	945173
mktcap	0				
DE	801	-.0637828	1.712447	-9.28	9.56
country	801	5	0	5	5
company	801	1967.076	1022.118	39	3134
profitmargin	17	7.153628	29.15577	-4.294964	120
logDE	238	-.3799458	1.453733	-4.60517	2.257588
logprofitm~n	11	-1.924048	3.061028	-4.682813	4.787492
assetturno~r	17	.9792272	.8828425	.0003442	2.482251
logturnover	17	-1.149309	2.479797	-7.974189	.9091657

-> country = IT

Variable	Obs	Mean	Std. dev.	Min	Max
companynam~t	0				
year	2,042	2016.594	2.271679	2013	2021
countryiso~e	0				
lastavaily~r	2,042	2019.797	.8612926	2013	2021
revenue	2,042	2585.293	6088.836	-1370	79575
EBIT	2,042	19.29089	523.0456	-12515	2621
employees	1,912	24.44927	27.21718	1	384
netasset	2,042	2388.883	5107.064	1	42689
mktcap	0				
DE	2,042	.9798531	2.878522	-9.79	10
country	2,042	4	0	4	4
company	2,042	1579.452	926.9212	9	3136
profitmargin	2,005	-.4924326	8.948205	-346.3	47.5
logDE	1,307	.1937917	1.354437	-4.60517	2.302585
logprofitm~n	1,169	-3.96615	1.835098	-9.158099	3.86073
assetturno~r	2,042	2.698331	4.041156	-.2799918	95.42857
logturnover	2,000	.366503	1.372706	-8.174421	4.558378

-> country = GB

Variable	Obs	Mean	Std. dev.	Min	Max
companynam~t	0				
year	2,181	2016.788	2.367026	2013	2021
countryiso~e	0				
lastavaily~r	2,181	2020.228	.4614938	2018	2021
revenue	449	71323.71	147943	1	932994
EBIT	474	6360.783	14846.71	-35317	135367
employees	1,192	37.27097	91.64362	1	845
netasset	2,181	16255.11	43359.98	1	711451
mktcap	0				
DE	2,181	.0879276	1.748084	-10	9.71
country	2,181	3	0	3	3
company	2,181	1604.227	898.0663	2	3133
profitmargin	446	.1840674	1.535602	-6.6	29.79293
logDE	770	-.5673795	1.467044	-4.60517	2.273156
logprofitm~n	379	-2.201621	1.38317	-6.399088	3.394271
assetturno~r	449	1.584872	2.752042	.0003877	34.43956
logturnover	449	-.1728459	1.252109	-7.855157	3.539206

-> country = FR

Variable	Obs	Mean	Std. dev.	Min	Max
companynam~t	0				
year	1,121	2016.779	2.324008	2013	2021
countryiso~e	0				
lastavaily~r	1,121	2019.868	.9921389	2014	2021
revenue	902	5943.66	14912.28	0	191170
EBIT	902	285.0909	2193.488	-26966	14224
employees	423	30.39007	49.87279	1	340
netasset	1,121	6453.996	15187.83	1	183516
mktcap	0				
DE	1,121	.3491436	2.115435	-9	9.98
country	1,121	2	0	2	2
company	1,121	1347.379	950.7941	13	3105
profitmargin	883	-.2740141	6.412029	-136	18.76
logDE	537	-.3145061	1.410685	-4.60517	2.300583
logprofitm~n	631	-2.516953	1.394137	-8.40167	2.931727
assetturno~r	902	1.462956	1.476875	0	14.52632
logturnover	883	-.0502876	1.140746	-6.665684	2.675962

-> country = ES

Variable	Obs	Mean	Std. dev.	Min	Max
companynam~t	0				
year	2,575	2016.598	2.27677	2013	2021
countryiso~e	0				
lastavaily~r	2,575	2019.87	.6884994	2013	2021
revenue	2,535	7389.833	18301.13	0	185670
EBIT	2,572	550.5303	2872.882	-31391	43774
employees	2,456	26.99267	50.66354	1	707
netasset	2,575	10591.71	25642.72	3	253348
mktcap	0				
DE	2,575	.0625476	1.74058	-9.2	9.99
country	2,575	1	0	1	1
company	2,575	1629.191	838.0689	29	3104
profitmargin	2,526	-.1026359	7.836974	-186.5	168.6338
logDE	844	-.4052431	1.341695	-4.60517	2.301584
logprofitm~n	1,936	-2.541031	1.419516	-7.576097	5.127729
assetturno~r	2,535	.9728208	.9249514	0	16.07107
logturnover	2,526	-.4173938	1.168364	-9.66218	2.77702

Appendix 2: Anova tests on the means of variables

```
. oneway DE country, tabulate

Country ISO |          Summary of DE
       code |        Mean   Std. dev.       Freq.
------------+------------------------------------
         ES |   .06254757   1.7405799       2,575
         FR |   .34914362   2.1154349       1,121
         GB |   .08792756   1.7480844       2,181
         IT |   .97985309   2.8785215       2,042
         NL |  -.06378277   1.7124472         801
         NO |   .65891289   1.9799398       5,832
------------+------------------------------------
      Total |    .4492008   2.0858988      14,552

                        Analysis of variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      1723.12961      5   344.625921     81.39     0.0000
 Within groups      61587.889   14546   4.23400859
------------------------------------------------------------------------
    Total           63311.0186  14551   4.35097372

Bartlett's equal-variances test: chi2(5) = 882.8262    Prob>chi2 = 0.000

.
```

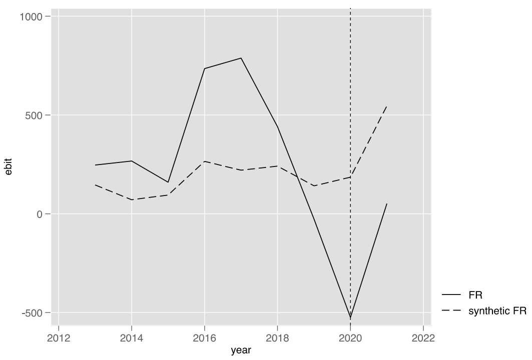
```
. oneway netasset country, tabulate

Country ISO |       Summary of netasset
       code |        Mean   Std. dev.       Freq.
------------+------------------------------------
         ES |   10591.713   25642.724       2,575
         FR |   6453.9955   15187.834       1,121
         GB |   16255.106   43359.981       2,181
         IT |    2388.883   5107.0636       2,042
         NL |   12177.129   54714.535         801
         NO |   57405.463   375370.28       5,832
------------+------------------------------------
      Total |   28819.517   240019.92      14,552

                        Analysis of variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      8.1746e+12      5   1.6349e+12     28.65     0.0000
 Within groups      8.3010e+14  14546   5.7067e+10
------------------------------------------------------------------------
    Total           8.3828e+14  14551   5.7610e+10
```

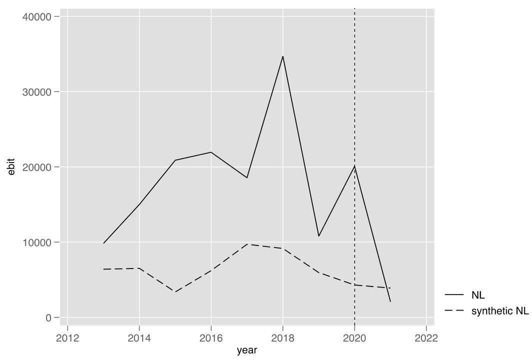
```
. oneway revenue country, tabulate

Country ISO |       Summary of revenue
       code |        Mean   Std. dev.       Freq.
------------+------------------------------------
         ES |   7389.8331   18301.126       2,535
         FR |   5943.6596   14912.283         902
         GB |    71323.71   147942.96         449
         IT |   2585.2933   6088.8365       2,042
         NL |   45253.294   62655.531          17
         NO |   32637.606   236471.97       5,829
------------+------------------------------------
      Total |    21438.07   169987.49      11,774

                        Analysis of variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      3.3008e+12      5   6.6015e+11     23.06     0.0000
 Within groups      3.3689e+14  11768   2.8628e+10
------------------------------------------------------------------------
    Total           3.4019e+14  11773   2.8896e+10

Bartlett's equal-variances test: chi2(5) =  2.5e+04    Prob>chi2 = 0.000
```

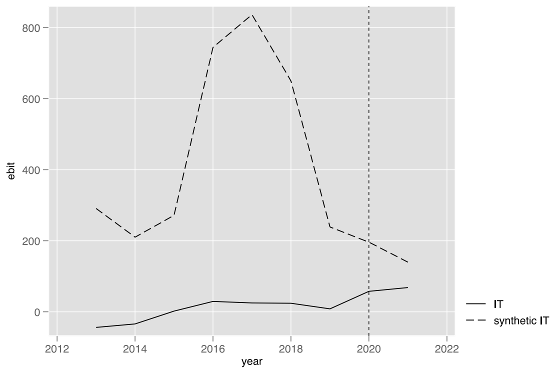
```
. oneway employees country, tabulate

Country ISO |       Summary of employees
       code |        Mean   Std. dev.       Freq.
------------+------------------------------------
         ES |   26.992671    50.66354       2,456
         FR |   30.390071   49.872792         423
         GB |   37.270973   91.643623       1,192
         IT |   24.449268   27.217183       1,912
         NL |         9.2   11.690397         310
         NO |   90.448732   819.74429       2,721
------------+------------------------------------
      Total |   46.514977   453.58902       9,014

                        Analysis of variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      7762471.72      5   1552494.34      7.57     0.0000
 Within groups      1.8466e+09   9008   204995.466
------------------------------------------------------------------------
    Total           1.8544e+09   9013   205742.997

Bartlett's equal-variances test: chi2(5) =  2.6e+04    Prob>chi2 = 0.000
```

```
. oneway EBIT country, tabulate

Country ISO |         Summary of EBIT
       code |        Mean   Std. dev.       Freq.
------------+------------------------------------
         ES |   550.53033   2872.8822       2,572
         FR |   285.09091   2193.4882         902
         GB |   6360.7827   14846.708         474
         IT |   19.290891   523.04562       2,042
         NL |   2870.3111   13021.396          45
         NO |   5832.5192   36629.207       5,832
------------+------------------------------------
      Total |   3275.6328   26050.727      11,867

                        Analysis of variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      9.1467e+10      5   1.8293e+10     27.25     0.0000
 Within groups      7.9613e+12  11861    671214936
------------------------------------------------------------------------
    Total           8.0527e+12  11866    678640397

Bartlett's equal-variances test: chi2(5) =  2.8e+04    Prob>chi2 = 0.000

. oneway employees country, tabulate
```

Appendix 3: Placebo testing the original synthetic control







Appendix 4: P values at a 2016 intervention date from left to right (EBIT, Debt-to-equity, Asset turnover, profit margin)