Measuring Impacts of Brexit on Migration and Regional Economic Growth of the UK: the Case of Wales

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I want to dedicate this thesis to my beloved parents, colleagues, friends, and more importantly, my grandparents in heaven.

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Summary

This thesis examines the nexus between Brexit and international migration to Wales and the Welsh economy, adopting a series of macro and micro-level datasets as well as multiple empirical methodologies. Wales as a significant component of the UK deserves in-depth studies in Brexit-related regional economic impacts.

In Chapter 1, the author offers comprehensive introduction to background and motivation for Brexit, research logic of this thesis, main findings, and thesis structure. Chapter 2 then focuses on a more detailed discussion of the history of Brexit, economic and political contributors of Brexit, and comparison of Brexit to other independence movements in Europe. This chapter sets up the background context for empirical studies in this thesis. In Chapter 3, the author provides critical information about the current literature of Brexit and its economic impacts in Wales and the UK, with major topics of impacts of Brexit on migration to Wales and the UK, on the Welsh and UK economy (GDP) and on international trade that will be examined in following empirical analysis chapters. It also gives several existing approaches utilised to analyse these issues, followed by the specific review of current Brexit studies in Wales.

Chapter 4 is the first empirical chapter, critically examining impacts of Brexit on international migration to Wales. It for the first time highlights the significance of region-based perspectives of Brexit-related migration studies in the UK and analyses how migrants with various patterns responded differently to Brexit and gives estimations of migration to Wales in the future.

Chapter 5 is the second empirical chapter, containing a series of empirical methods to measure impacts of Brexit on major factors of the Welsh economy, namely international trade between Wales and other countries, inward FDI in Wales, and overall economic growth in Wales measured by GDP per capita.

Chapter 6 is the third empirical chapter, revisiting economic impacts of Brexit in Wales from a firm-level perspective. It utilises the FAME database, a panel data model, and additional PSM-DID analysis to critically illustrate how Brexit affects corporate productivity in Wales. The Welsh economy, similar to the UK economy, is largely made up of the private sector, thus corporate performance and resilience to Brexit require more academic attention.

Chapter 7 concludes this thesis with summary and discussion of future developments.

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Abbreviations

Brexit	UK leaving the European Union
BVD	Bureau Van Dijk
DID	Difference-in-Difference
DSGE	Dynamic Stochastic General Equilibrium
EU	European Union
FDI	Foreign Direct Investment
FE	Fixed Effect
FEVD	Fixed-Effect Vector Decomposition
GDP	Gross Domestic Product
GVA	Gross Value Added
INSEE	Institut National de la statistique et des études économiques (France)
IV	Instrumental variables
LFS	Labour Force Survey
NIGEM	National Institute Global Econometric Model
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
ONS	Office for National Statistics
PSM	Propensity Score Matching
RN	National Rally (France)
SCM	Synthetic Control Method
SDID	Synthetic Difference-in-Difference
SVAR	Structural Vector Autoregression
TFP	Total Factor Productivity
UK	United Kingdom
US	United States
WHO	World Health Organization
WTO	World Trade Organization

Chapter 1 Introduction

1.1 Background and Motivation

On 23 June 2016, a historic referendum decided that the UK would exit the European Union (EU) sometime in the future (i.e., "Brexit"), and the UK's EU membership would therefore expire. After rounds of protracted negotiations between the UK and EU, an agreement was drafted in 2018, revised in 2019, signed on 24 January 2020, and finally became effective on 1 February 2020. After the one-year transition period in 2020, the UK formally completed all procedures of Brexit with the ending of this transition period at 11 pm on 31 December 2020, meaning the UK formally entered the post-Brexit era in 2021.

Rounds of polls were organized before the 2016 Referendum and political analysts revealed that numerous factors led to the growing support for Brexit including unfair trade between the UK and EU, the UK's independence of the socioeconomic and political decision-making process, anti-establishment populism against the elite, and many others (Smales, 2017). Among them, reluctance to embrace more migrants from the rest of the world to the UK ranked at the forefront in almost all polls before the referendum, indicating that migration to the UK is one of the most important and controversial issues with regard to Brexit. However, according to ONS data¹, the number of long-term non-EU migrants to the UK has exceeded that of EU migrants in most years since the 1990s except for the period from 2013 to 2018 when the rapid increase in EU migrants to the UK was, according to several analysts, believed to result from the "speed-up" effect of migration due to growing concerns over Brexit before and after the 2016 Referendum (Jancewicz et al., 2020). It also clearly shows that the "fear" of tremendous waves of EU migrants to the UK seems to lack statistical evidence.

In spite of the migration statistics, the final Brexit agreement has resulted in the current UK immigration policy which imposes stricter restrictions on EU migrants but keeps the previous immigration requirements for non-EU migrants. It is important to note that even though the fact that non-EU migrants occupied the majority of migrants to the UK in history, which might relieve the toxicity of EU-migration-targeted restrictions. However, it should also be noted that due to varied economic and migration ties between different regions of the UK (i.e., England, Wales, Scotland, and Northern Ireland) and the EU, the number of EU migrants to some UK

¹ <u>https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/internationalmigration</u>

countries (such as Wales) might be significantly more than that of non-EU migrants, which makes relevant studies valuable to country-level policies of migration to the UK amid the Brexit's one-size-fits-all restrictions on migration to the UK. To the best of my knowledge, few of the current bulk of studies on impacts of Brexit on migration to the UK have arrived at the regional stage while the majority of existing literature focuses on the nationwide impacts of Brexit on migration, international trade, and economic growth.

More importantly, heterogeneous patterns of migration to the UK also exists according to different features of industries and different levels of skills owned by groups of migrants. For example, the manufacturing industry in the UK embraces more EU migrants than non-EU migrants and the majority of migrants in this industry have low and mid-level skills such as manufacturing and accounting skills, who will face high possibilities of being replaced by automated technologies and intelligent manufacturing innovations (Vergas-Silva & Rienzo, 2019). With additional restrictions on migration, EU migrants with low and mid-level skills are expected to suffer more from Brexit than their counterparts, i.e., non-EU migrants. However, it is not definite that EU migrants form the vast majority of low and middle-skill labour while non-EU migrants tend to occupy more high-skill vacancies in the UK since the industrial and labour patterns can extremely vary in different UK countries and cities, which again requires empirical studies based on local databases of migration.

Last but not least, the potential negative impacts of Brexit on migration to the UK might lead to higher risks in business operations for multinational corporations (MNCs), causing shrinking supply such as decreasing investment (Feldmann & Morgan, 2021). This could in turn reduce the labour demand and let the unemployment rate rise rapidly in the UK. Meanwhile, since the UK and EU reached an agreement on trade in 2020 which makes the UK leave the EU customs union, single market, and VAT area, several studies claim that business operators might have to increase business costs for additional trade procedures such as transportation paperwork and customs inspections across the border. According to the latest agreement, i.e., the "Windsor Framework"², green and red lanes are introduced to reduce paperwork and extra checks on goods that are shipped to Northern Ireland from EU countries, which is estimated to have slightly positive impacts on bilateral trade between the UK and EU (Murray & Robb, 2023).

As a political type of external shock, Brexit is expected to impact migration to the UK and regional economic growth in all parts of this country immensely. Given the lessons learned

² See Windsor Framework file: <u>https://www.gov.uk/government/publications/the-windsor-framework</u>

from external shocks of immigration restrictions and their significant impacts on migration and regional development in history and the paucity of country-level studies on this issue, it is very important to focus on how Brexit had and will have impacts on migration to the UK and economic growth in the UK from a regional perspective. Wales has kept close relationships with the EU regarding trade and migration. Over 60% of the total value of Welsh goods is destined for the EU since the 1990s³ and almost 50% of migrants to Wales have come from EU countries since 2004⁴, making Wales one of the most important regional partners of the EU in the UK. Since Brexit mainly targets the relationship between the UK and EU and imposes additional restrictions on EU migration and goods, it is estimated that such close ties between Wales and the EU could make Wales an excellent case for further analysis on impacts of Brexit on migration and economic growth in the UK with a regional lens. Additionally, Wales also shares opportunities with non-EU countries and has focused on international trade (over 60% of total import value comes from non-EU countries) and higher education which has attracted thousands of non-EU students and migrants to Wales.

Therefore, the first objective of this thesis is to answer the question of how Brexit impacted migration to Wales and economic growth in Wales by modelling the causal effects of Brexit on migration and fluctuations in the Welsh economy. The second objective is to project such impacts in the future by incorporating recent external shocks such as the Covid-19 pandemic and the Ukrainian War that might have mixed impacts on migration to Wales and the Welsh Economy. Finally, we hope to establish a methodological channel which connects the impacts of Brexit on migration to Wales and on the Welsh economy, which can help to provide a regional paradigm of regional economic analysis on policy shocks, international migration, and local economic developments in the context of Brexit. To answer these questions, multiple methodologies can be applied, such as the synthetic control method (SCM) and Propensity Score Matching (PSM) Difference-in-Difference (DID) method which will be thoroughly discussed in the following sections.

1.2 Research Logic and Main Findings1.2.1 Research Logic

³ Latest import and export data can be found at: <u>https://www.gov.wales/welsh-international-goods-trade-2022-html</u>. Historical data can be found at: <u>https://www.ons.gov.uk/businessindustryandtrade/internationaltrade</u>

⁴ See ONS Population by country of birth and nationality from the Annual Population Survey (2004-2021).

First, this thesis focuses on the impacts of Brexit on migration to Wales, a significant immigration destination in the UK. EU migrants have become a major part of all migrants to the UK since the late 1990s and discussions on imposing extra limits on EU migrants directly caused the growing popularity of Brexit and its potential "benefits" of reducing EU migrants to the UK to protect local job opportunities. It is important to note that these job opportunities are mainly for low and mid-skill workers while the majority of labour migrants with low and mid-level skills have been EU migrants in the UK (Fernández-Reino et al., 2021). Wadsworth (2010) claims that low and mid-skill labour migrants in the UK are more likely to suffer from high substitution effects that make these workers more vulnerable to technological innovations and have higher risks of being unemployed. As a result, combined with a populist narrative driven by Euroscepticism in the UK, controlling EU migration has become a major argument of pro-Brexit theories. Thus, it is essential to examine how new restrictions on migration (especially on EU migration) due to Brexit had impacts on actual patterns of migration to the UK and how such impacts differ in varied groups of migrants by country of birth and industries. Considering the close economic and migration ties between Wales and the EU, we use the case of Wales to perform the empirical analysis on reviewing such impacts from 2010 until 2020 with the 2016 Referendum included as a major turning point of UK immigration guidelines and principles.

Second, fluctuations in recent years such as the Covid-19 pandemic from 2020 until 2022 and the Russian Invasion of Ukraine starting in February 2022 might cause additional impacts on the decisions of migrating to the UK amid the estimated long-term effect of Brexit on migration. Migration brings the spread of virus; thus, the pandemic is expected to extremely discourage migration around the world by forcing migrants to postpone the migration due to severe risks of infection and death especially during the early stage of the outbreak (Hari et al., 2023; Khanna, 2020). With the end of the Covid-19 pandemic in 2022, the Ukrainian War became another "black swan" event expected to encourage migration from Eastern European countries bordering Ukraine (Guild & Groenendijk, 2023). One root cause of the war is growing conflicts between Russia and NATO (more accurately, the United States as the controller of NATO), which has lasted for decades and decides the perpetuation of geopolitical tensions. With the fear of potential further confrontations in the Eastern European region, migration from this region to the UK is estimated to increase in the coming years (Liadze et al., 2023), indicating the significance of conducting research on the impacts of the increase in these migrants on the economic growth in the UK. More importantly, Wales has embraced thousands of Eastern

European migrants in the past few decades and has become one of the most important migration destinations in the UK. As a result, we hope to estimate the patterns of future migration to Wales amid the long-term effects brought by the pandemic and the Ukrainian War.

Then, this thesis turns to focus on the broader Welsh economy from perspectives of macroeconomic analysis and adopts three major variables to examine impacts of Brexit on the Welsh economy, i.e., trade volumes, FDI inflow, and GDP per capita, which measures international trade activity, investment, and overall local economic growth in Wales, respectively. A series of methodologies will be utilised for this section, such as Synthetic Control Method (SCM), Synthetic Difference-in-Difference (SDID), SVAR Markov Switching model, and NIGEM model, to comprehensively decompose economic impacts of Brexit in Wales.

These methods are complementary since the major purpose of utilising these methods is to measure impacts of Brexit on inward immigration to Wales and the Welsh economy, except for the NIGEM model which aims to provide a general forecast of such impacts in next few years. Costs and benefits are as below:

(1) SCM (See Section 5.5.3)

Costs: SCM requires a large number of pre-treatment variables and data for other regions to construct a reliable synthetic control scheme (Abadie et al., 2010). Parallel trends of pre-treatment variables in other regions aligned to Wales should also be met. For example, Gietel-Basten et al. (2019) use SCM to analyse impacts of the "one-child policy" in China and here, SCM requires pre-policy data, comparable donor countries unaffected by similar policies, and consistent outcome variables such as fertility rates. Relevant predictors (e.g., GDP, education) ensure synthetic control mimics China's pre-policy trends. Absence of confounding factors and optimized weighting for donor countries are essential to isolate the "one-child policy" impact. For the post-intervention period, the fertility rate of similar countries with their corresponding weights is used to construct the synthetic China TFR, which represents the fertility rate if there were no policy intervention.

Benefits: SCM is particularly useful for estimating causal effects when a single treatment is being studied (like Brexit), especially for small open economy. It offers clear visual representation of the treatment effect and counterfactual outcomes and provides robust causal estimates when randomised experiments are not feasible with regard to economic activities and public policies (Gilchrist et al., 2023).

(2) SDID (See Section 5.5.1)

Costs: Like SCM, SDID also requires general parallel trends of data for variables in comparison groups of regions to construct a control group (Porreca, 2022), in the case of this thesis, namely two regions in France and Germany in this thesis.

Benefits: SDID is particularly beneficial when there is concern about underlying time trends or when changes over multiple periods need to be considered. It allows for more rigorous testing of causal effects over time and can highlight the impact of policy shocks such as Brexit on economic growth or corporate TFP (Porreca, 2022).

(3) SVAR Markov Switching (See Section 5.5.2)

Costs: It is complex and requires a strong understanding of dynamic systems, as well as robust time-series data. It also assumes that the economic system can switch between different regimes and there should be a clearly defined switch of regime that leads to structural changes to economic activities such as productivity, trade, and consumption (Hu et al., 2018).

Benefits: It can capture complex economic relationships and shifts in the economy, such as sudden changes induced by Brexit by including regime-switching changes to major macroeconomic measures.

(4) NIGEM (See Section 4.2.4)

Costs: NIGEM requires significant computational resources and expert knowledge to interpret. It might not capture firm-level heterogeneity as well as micro-level models like PSM-DID.

Benefits: It provides comprehensive insights into the broader economic impacts of Brexit and is ideal for understanding how Brexit impacts the overall Welsh economy by integrating bulk of data from numerous sectors and countries.

In terms of general economic performance in Wales, in 2022, Wales experienced a 3.8% GDP growth, below the UK's 4.1%, and GDP per capita in Wales was £24,443, significantly lower than UK average £33,497⁵. Wales has the highest economic inactivity rate in the UK, with one in four individuals economically inactive, though the jobless rate is better than the UK average⁶. However, the Welsh economy benefits from strong economic ties with dominant Wales-EU trade and

⁵ https://www.gov.wales/regional-gross-domestic-product-1998-2022

https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/regionallabourmarket/december2024

investment, making Wales a vulnerable economy that could be significantly impacted by Brexit (Khorana & Perdikis, 2018). Thus, it is more than important to examine how the Welsh economy responded to Brexit marked by the 2016 Referendum and how trade, investment, and local economic growth can eliminate negative impacts of Brexit in the future.

Year	GDP growth rate in Wales	GDP growth rate in UK
2010	2.9	2.2
2011	3.7	1.1
2012	1.6	1.5
2013	1.8	1.8
2014	1.7	3.2
2015	2.1	2.2
2016	2.6	1.9
2017	1.9	2.7
2018	2.6	1.4
2019	1.5	1.6
2020	-10.7	-10.3
2021	5.3	8.6
2022	3.8	4.8

Table 1.1 Comparison of GDP growth rates in Wales and UK average

Note: All units are percentages. Sources are ONS GDP data of the UK⁷ and the Welsh Government⁸. Highlighted data means GDP growth rates in Wales lower than UK averages in that year.

Last but not least, empirical sections of this thesis end up with the last empirical chapter focusing on the nexus of Brexit and corporate productivity in Wales. The private sector which consists of thousands of companies in Wales is the major contributor to economic growth in Wales (Brill et al., 2015) and how they were impacted by Brexit requires more analysis. This section applies the panel data model and PSM-DID analysis to validate impacts of Brexit on corporate productivity measured by corporate TFP in Wales. The PSM-DID analysis also for the first time involves a comparative study that considers firms in Brittany, France as the control group and firms in Wales as the treatment group. Brittany is chosen as the comparator region majorly due to economic similarity to Wales (See Table 1.2). Moreover:

- (1) Spatial economic similarity: Both Wales and Brittany are located in peripheral areas of their perspective countries and share strong economic connections with other EU countries, and such connections are even stronger for Brittany since France itself is an EU member.
- (2) Local economic growth: Wales and Brittany have similar scales of economic growth measured by GDP per capita (£27,274 for Wales and €33,648 for Brittany⁹), similar

⁷ https://www.ons.gov.uk/economy/grossdomesticproductgdp/timeseries/ihyp/pn2

⁸ <u>https://www.gov.wales/regional-gross-domestic-product-1998-2022</u>

⁹ https://www.insee.fr/fr/statistiques/serie/010751771

industrial structures with focus on agricultural and manufacturing industries, and similar small capitals serving as local economic hubs (Le Berre, 2017). It is also worth noting that both regions have a strong manufacturing sector, especially in aerospace, marine, automotive, and engineering, and significant agricultural sectors.

- (3) Similar trade patterns: Other EU countries are dominant trade partners of both Wales and Brittany and before Brexit, both of them belong to EU free trade area (EFTA).
- (4) Cultural and institutional similarities: Both Wales and Brittany have their own regional languages and local identities, and both of them re governed under decentralised regional governments (the Welsh Government and Regional Council of Brittany).By comparing firms in these two extremely economically similar regions, we are able to justify the causal effects of Brexit on corporate productivity feasibly.



Table 1.2 GDP per capita growth in Wales and Brittany (£)

Note: Data is in pound sterling. For GDP per capita in Brittany, the original data is in euro and the estimation of GDP per capita in Brittany in pound sterling is calculated with the yearly average euro-pound exchange rate in each year. Sources: ONS GDP data¹⁰ and population data¹¹ for Wales, and INSEE data¹² of GDP per capita for Brittany.

1.2.2 Main Findings and Contributions

There are several main findings of this study.

(1) Chapter 3 has demonstrated that Brexit has significantly negative effects on certain groups of migrants in Wales, with these impacts likely to persist over the next five years. Specifically,

¹⁰ https://www.gov.wales/regional-gross-domestic-product-1998-2022

 $[\]label{eq:https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestima$

¹² https://www.observatoire-des-territoires.gouv.fr/pib-regional-par-habitant

Brexit has an overall adverse impact on EU migrants, while non-EU migrants are not significantly affected. Among EU migrants, those earning less than £30,000 annually in the construction and manufacturing sectors are the most critically impacted. Conversely, non-EU migrants seem to benefit from Brexit-related restrictions on international migration to Wales, particularly from the EU region, leveraging their higher-than-average skills and education. The findings reveal that migration patterns in Wales closely mirror those in the rest of the UK, providing insights for further studies on the impact of migration in other UK regions to create a comprehensive understanding.

(2) Using the Synthetic Difference-in-Difference (DID) method, we find that the 2016 Referendum in Q2 2016 has had notable effects on the import and export dynamics of Wales. Specifically, it significantly increased the influx of goods from non-EU trading partners to Wales while simultaneously discouraging exports from Wales to both EU and non-EU countries. The actual implementation of Brexit in Q1 2021 appears to have minimal influence on trade dynamics between Wales and its partners. Our observations suggest that factors previously identified in studies—such as the clarification of Brexit-related trade policies, the completion of free trade negotiations between the UK and the EU, and the stabilization of trade flows between the UK and the rest of the world—may explain why the effects of Brexit on trade between Wales and its counterparts have diminished since 2021. The high proportion and resilience of Wales-EU trade since 2021 might explain why the impact of Brexit on trade between Wales and other countries has been insignificant.

(3) It is found that concerns over fluctuations in economic growth in Wales, the exchange rates of the pound sterling, and the increasing political and economic risks in the UK might be potential mechanisms through which Brexit-related events have negatively impacted investment confidence in Wales. Overall, the negative impacts of the 2016 Referendum on inward FDI in Wales are more significant than those of the subsequent Brexit agreements.

(4) The Synthetic Control Method (SCM) is used to create a Doppelganger Wales based on macroeconomic data from three regions in France and Germany that have very similar economic patterns to Wales. It is found that the 2016 Referendum led to a decrease in real GDP per capita in Wales compared to the ideal Doppelganger Wales, which did not experience the referendum. The gap in GDP per capita between real Wales and Doppelganger Wales began to narrow in 2021, indicating the diminishing marginal impacts of Brexit on economic growth in Wales.

(5) Regarding the impacts of Brexit on corporate Total Factor Productivity (TFP) in Wales, the panel data analysis indicates that Brexit has significant effects on corporate TFP, supported by a series of robustness tests. Spatial heterogeneity analysis reveals that the negative impacts of Brexit on corporate TFP are more pronounced for firms in South Wales, where the number of firms is significantly higher and business connections with the EU are more frequent. Additionally, firm heterogeneity analysis shows that companies with closer business ties to the EU experience a more significant shock to corporate productivity due to Brexit. Lastly, trade, FDI inflow, and inward migration are identified as three mechanisms through which Brexit affects corporate TFP in Welsh firms by reducing the growth rates of all three variables.

The most important contributions provided by this study include: (1) it aims to apply a subnational lens to analyse economic impacts of Brexit in the UK by using the Welsh economy as the case; (2) it can encourage relevant studies applying subnational data and methodologies to narrow the research gap of region-based Brexit studies; (3) it also tries to adopt firm-level data and micro-econometric approaches to measure impacts of Brexit on corporate productivity in Wales, providing a precedent for other research in the field of regional economic analysis on Brexit.

1.3 Thesis Structure

Before entering sections on reviewing and forecasting the impacts of Brexit on migration to Wales and the Welsh Economy, the following Chapter 2 provides a detailed review of the background of Brexit and sets the scene for this research, including the history of Brexit-related ideologies, the relationship between Brexit and Euroscepticism, and development of the 2016 Referendum. Specifically, this chapter focuses on how migration, trade, and several other topics have become major controversies between anti and pro-Brexit voters in the past few decades and whether the data of these variables support the Brexit narratives. It is followed by Chapter 3 which includes relevant literature on major research topics covered in this thesis, i.e., impacts of Brexit on migration to the UK, on the labour market and GVA in the UK, and on international trade between the UK and its trade partners, concluded with main hypotheses that need to be analysed. Chapter 4 will turn the attention to impacts of Brexit on migration to Wales and present a review analysis on how migration to Wales responded to Brexit since the 2016 Referendum with a Wales-based gravity model with FEVD settings and an attempt to forecast future patterns of migration to Wales by taking advantage of NIGEM model. In Chapter 5,

reviewing and forecasting the impacts of Brexit on GVA, international trade, and the labour market in Wales will benefit from the Welsh-version NIGEM model co-developed by NIESR and Cardiff University and several other well-developed models such the network trade model with region-sector level input-output linkages, which is developed to measure the impacts of trade shocks, i.e., Brexit-related reconstruction of trade policies in the UK. Discussions on economic impacts of Brexit in Wales will be combined with analysis on the labour market in Wales to measure changes in unemployment rates and income levels across different industries after Brexit. Chapter 6 mainly focuses on how migration and local economic growth in leftbehind regions in Wales and the UK responded to Brexit and tries to provide policy implications to recover the economy and overturn the out-migration waves from these regions in the post-Brexit era. Finally, in Chapter 7, I hope to perform a more detailed analysis on impacts of Brexit on local businesses in Wales by taking advantage of firm-level data and focusing on such impacts based on corporate TFP. Chapter 8 concludes this thesis.

Chapter 2 Brexit: Setting the Scene

This chapter provides essential detailed background information about Brexit. The history of Brexit is demonstrated from both political and socioeconomic perspectives (Section 2.1) by introducing major economic and political reasons for exiting the EU and connecting the ideology of Brexit with the existence of left-behind regions where political discontent and economic depression grow in the UK. The main purpose of Brexit, according to pro-Brexit voters, is to regain the independence and autonomy of public policies (Trommer, 2017), sharing some similarities of purposes with other independence movements such as the Catalan Independence Movement in Spain and isolationism-driven campaigns such as far-right policies promoted by AfD in Germany and RN in France and the theory of "America First" during the Trump administration (Van Kessel et al., 2020). However, arguments for Brexit have considerable differences compared to all these movements and have deep roots in the complexity of the UK-EU relationship, features of the UK economy, and considerable EU migration. Hence, to understand the socioeconomic similarities and differences, I introduce a comparative analysis on Brexit and other recent political and economic agendas in multiple countries (Section 2.2) and mainly focus on their impacts on migration and local economic growth in move-in regions. Section 2.3 concludes this chapter with an emphasis on clarifying economic and political narratives of Brexit as an essential scene-setting procedure of this thesis.

2.1 Brexit as an Economic and Political Agenda2.1.1 Why Did the UK Join the EU?

First, it is important to know how and why the EU was formed before discussing why the UK decided to join the EU. The Second World War created massive chaos and disasters in almost all European countries including the UK in the 1940s. Some European countries started to rethink establishing a strong union of Europe to prevent world wars from happening again after the war. Despite the fact of anti-war movements, most European countries lost their global influence compared to the US and the USSR (two superpowers in the post-war era), which reaffirmed their willingness to maintain their political powers (Dinan, 2004). In 1949, the Council of Europe was established as the first prototype of the EU. Since the coal and steel industries were already highly developed in the Ruhr district and Luxembourg (Gilles, 2003), some European countries decided to start collaborating in these fields. In 1951, the Treaty of

Paris was signed by France, Italy, West Germany, Belgium, Netherlands, and Luxembourg so the European Coal and Steel Community (ECSC) was created in 1952. In 1957, another two communities, the European Economic Community (EEC) and the European Atomic Energy Community (Euratom) were established. In 1967, these communities merged and were known as European Communities (EC). In the next three decades, these communities experienced rounds of enlargements and some major European countries including the UK, France, and Germany became core members of communities. In 1993, the European Union was finally established under the Maastricht Treaty. The EU was formed because European countries had shared values and benefits, such as the aspiration of creating free markets and decisive power of defence (Dinan, 2004).

Second, it is also necessary to understand why and how the UK joined the EU. Since UK's economy was struggling to recover from the world war, the UK tried to apply for entry into EEC in 1961, seeking economic recovery aid and more regional cooperation. However, the former President of France, Charles de Gaulle, vetoed the UK's applications to join the EEC in 1963 and 1967 since he believed the UK's existence would erode the independence and autonomy of European countries due to the close relationship between the UK and the US (Ludlow, 2007). After rounds of negotiation, the UK finally became a member of the EC in 1973, benefiting from low tax rates, free movement of labour, and other exclusive treatments among EEC members (Dinan, 2004). In 1975, a national referendum was held for the first time to decide whether the UK should stay in the EC since some politicians from Labour Party believed that the membership of the EC caused higher unemployment rates and inflation rates in the UK (Rowley, 1996). The result was to remain as a member of EC with 67.23% of voters voting for remain and 32.77% voting for leave.

Some researchers, such as Evans (2012) and Saunders (2018), claim that the result of the 1975 Referendum shows that the necessity of remaining the membership of EC as a significant source of economic and trade benefits was broadly approved by British citizens. Saunders (2018) suggests that the UK witnessed a strong "centripetal force" towards the EU, leading to low support rates for Brexit and thus the first failed Brexit attempt. In 1993, European Union (EU) was finally established under the Maastricht Treaty and the UK became a member of the EU. Some researchers believe that the main reason for joining the EU is economic benefits. For example, Campos et al. (2019) analyse the GDP per capita of UK and EU founding members and argue that the UK joined the EU (and formerly, EC) to stop its economic depression since UK's GDP per capita experienced a steady decline compared to EU founding countries from 1945 to 1972 but it became stable from 1973 to 2010. Some other researchers, however, tried to highlight the political motivations behind the decision of membership. Darwin (2011) notices the changing political landscape among all Commonwealth countries after 1945 and claims that the UK intended to make the membership of the EU as well as its predecessors become a symbol of political existence since it was losing its control of the Commonwealth countries in the 1940s. Furthermore, Hurt (2010) believes that EU membership could make it possible for the UK to have more political impacts on global issues including trade and immigration, national security, and competition against fast-growing economies such as Japan and then China, compared to not joining the EU.

2.1.2 Socioeconomic Reasons for Brexit

Scepticism about how integrated the UK should be in the EU and economic projects behind the EU single market triggered more and more debates on the UK-EU relationship for decades (Emmerson et al., 2016; Hix, 2018). One major argument that pro-Brexit voters believe is joining the EU ruined the sovereignty of the UK, making it difficult for the UK to conduct independent social and economic domestic policies (Auer, 2017). Sovereignty covers numerous fields of political and economic policies that construct domestic social and economic developments. Among these fields, pro-Brexit voters focus on the independent tariff system, immigration policies, and fair-trade agreements to maximize the UK's own benefits (Gee, 2016).

The design of the EU is to conduct centralized public policies of the union by transferring partial rights of sovereignty of all EU members, implying that the "erosion" of the sovereignty of each single EU member seems to be inevitable. Multiple studies have focused on correlations between transferring sovereignty to the EU and local economic growth in several EU countries and found that the impacts of becoming an EU member had spatial heterogeneity across different countries with higher negative coefficients for wealthier EU members such as the UK, France, and Germany (Bellamy, 2017; Bickerton et al., 2022). Some other researchers claim that low and mid-skill domestic workers in several EU countries suffered from fierce jobseeking competition, rising unemployment rates, and stagnated income due to centralized trade and immigration policies of the EU (Cangiano, 2014).

According to numerous polls in 2016 before the historic referendum, the most important reason for Brexit was "the principle that decisions about the UK should be made by the UK", showing that sovereignty became the major concern among pro-Brexit voters (Amador Diaz Lopez et al., 2017). The sense that becoming an EU member eroded the independence of domestic policies in the UK has been considered a strong motivation for pro-Brexit voters to end the EU's influence on the UK.

Their concerns might not be unreasonable. First, the majority of EU migrants in the UK have had the purpose of long-term or permanent UK residency with the demand for jobs, education, and healthcare. Labour migrants form the main body of EU migrants to the UK and endeavour to prepare for long-term careers by applying for workers' visas since the 2000s, imposing negative perceptions on British workers with fear of fierce competition and higher risks of losing jobs, training opportunities, and other benefits (Agnew, 2020). According to ONS data, the major purpose of migration for EU migrants has been working in the UK and the growing influence of EU migration might have caused concerns across the UK.

Second, the European debt crisis from 2009 until the end of 2010 hit the eurozone and encouraged the theory that leaving the EU would benefit the UK. This crisis was caused by a sudden stop of foreign capital flows into several EU countries (i.e., Greece, Portugal, Ireland, Spain, and Cyprus) that had considerable deficits and relied on foreign lending and had severe impacts on the UK economy. Beker (2014) analyses the impacts of the eurozone crisis and finds that, in the UK, the GDP growth rate decreased by 15%, the unemployment rate increased by 7%, general government gross debts increased by 8%, and the sterling experienced rapid depreciation due to the 2008 Recession and the European Debt Crisis from 2008 until 2013. Figure 2.1 shows similar shocks on economic growth in several EU countries including the UK. Meanwhile, EU membership required the responsibility of financial stability to prevent a eurozone crisis from developing into a global financial crisis, and the UK had to cooperate with other EU members to provide a \$143 billion bailout package for five EU members in crisis for three years from 2010, which became a heavy debt burden (See Figure 2.2 for details). The crisis also encouraged multiple EU countries to conduct fiscal austerity policies and the aggregate demand rapidly shrank in the eurozone, causing negative effects on UK supply chains, stagnant UK economic growth and rating agencies' downgrades of the Bank of England (Alsakka et al., 2014).

Figure 2.1 Economic growth during the 2008 Recession and European Debt Crisis



Source: The World Bank database, 2001-2012.



Figure 2.2 Debt Crisis in the UK and the Eurozone

Source: The UK and Eurozone history of general government gross debt, Eurostat data, 2000-2016.

Finally, migrants and refugees originating from the Middle East to the UK increased rapidly since the Arab Spring in 2010, and some of them has stayed in EU countries for a period with EU residence permits before they moved to the UK (Kang, 2021). Kirkwood (2017) considers such migration as a "triple jump" from Arabian move-out countries to southern European

countries, then to the CEE region, and finally to destinations of western European countries such as the UK and France. The migration waves to the European mainland and the UK are combined with increasing religious conflicts and even terrorist attacks driven by radical Islamic extremism and ISIS groups. In conclusion, as a political agenda, Brexit is considered to result from migrants' preference for long-term residency in the UK, and negative impacts of the European debt and refugee crises on the job market, productivity, social welfare, and overall economic growth in the UK.

2.1.3 Political Reasons for Brexit

With a number of supports for leaving the EU in both Conservative and Labour parties, the idea of leaving the EU became mainstream in the Conservative Party since the 2010s but we also observed significant disagreements inside the party. In 2011, several backbencher Conservative MPs insisted to have a Brexit referendum regardless of Prime Minister Cameron's strong opposition. Even though the motion for a Brexit referendum was vetoed with 111 affirmative votes and 483 dissenting votes, the split between the pro and anti-Brexit MPs in the Conservative Party became conspicuous¹³. Moreover, the popularity of Brexit became widespread in the party. In 2012, over 80% of Conservative MPs supported Brexit and only a small proportion of them supported the UK remaining in the EU¹⁴. By the end of 2012, the support rate for the Conservative Party was 32% while that for the Labour Party was significantly higher (40%), according to a poll by the ICM and Guardian¹⁵. Considering the potential backfire in the party, Cameron promised that a referendum would be organised to decide whether the UK should stay in the EU before 2017 if the Conservative Party won the general election in 2016. Then, he led the Conservative Party to have won the 2016 election by coordinating pro and anti-Brexit MPs in the party while the PM himself switched to a staunch anti-Brexit position and was challenged by Boris Johnson, who has been known as the leader of pro-Brexit MPs. With the result of the 2016 Referendum coming out, Cameron resigned to take responsibility for failing to prevent Brexit.

Several studies attribute Brexit to conflicts between Cameron and Johnson and the final success of Johnson's pro-Brexit agenda (Clarke et al., 2017; Bale, 2022). However, Alexandre-Collier (2022) claims that political disagreements inside the Conservative Party was one reason for the

¹³ See UK Parliament News Article: <u>https://committees.parliament.uk/committee/202/backbench-business-committee/news/177832/backbench-business-debate-on-the-holding-of-an-eu-referendum/</u>

¹⁴ <u>https://ukandeu.ac.uk/mps-constituents-on-brexit/</u>

¹⁵ https://www.theguardian.com/world/2012/dec/26/euroscepticism-growing-voters-poll

essence of populist democracy which illustrates a new populist rhetoric in the form of Brexit, anti-immigration, and anti-establishment discourse. Hayton (2021) also reveals that the populist and isolationist statecraft inside the Conservative Party contributed to Brexit. The current political studies on reasons for Brexit include the following two major arguments.

1) Political discontent and polarization. The political discontent leading to Brexit mainly presents in the form of distrust of existing public policies in the UK. Jennings et al. (2017) reveal a long-term increase in political distrust of the decision-making system and politicians in the UK since the 1980s. Dustmann et al. (2017) claim that the 2008 global financial crisis, the 2010 European Debt Crisis, and the refugee crisis mentioned in previous sections contributed to the erosion of political trust and a great number of UK citizens believed that the current political system failed to protect the social and economic benefits in the country. Some of them also believe, which is consistent with our findings in previous sections, that independent governance in the UK without being impacted by the EU would greatly reduce government debts and migrants and increase the efficiency of public policies. Regarding political polarization, Figure 2.3 shows the severity of divergence in public opinions about Brexit, and we can see that pro-Brexit voters clustered in Midlands and East of England while anti-Brexit voters were mainly in cities of England and Wales, most parts of Scotland, and Northern Ireland. Murray et al. (2017) find that Brexit exacerbated and exposed a high level of political polarization in the UK. In their study, the proportions of leave votes in all samples ranged from 21.4% in Lambeth to 75.6% in Boston, showing that political polarization has unveiled significant spatial discrepancies across the country. In terms of demographic patterns, young voters are more likely to support remaining in the EU than senior voters and voters with higher education prefer not to support Brexit while the majority of leave votes came from voters without higher education degrees, according to the data of the 2016 Referendum¹⁶. Osuna et al. (2021) also find that the sense of political discontent toward migration, trade, and public policies was significantly reinforced by local political and socio-economic trajectories, and the populist narrative became dominant in certain areas and extremely impacted citizens' voting behaviour, leading to a more severe polarization. Jennings & Stoker (2018) reveal that the wide

¹⁶ See full 2016 Referendum result data published by The Electoral Commission: <u>https://www.electoralcommission.org.uk/sites/default/files/2019-07/EU-referendum-result-data.csv</u>

use of social media boosted divergent opinions on Brexit-related debates and caused polarized public values.



Figure 2.3 Results of the 2016 Referendum by local councils

Source: The 2016 Referendum result data published by The Electoral Commission.

2) Anti-establishment belief. The anti-establishment theory originates in distrust of elites and politicians and promotes rebellion of the working class to regain the control of political and socioeconomic rights of the society (Barr, 2009). As we have witnessed, the anti-establishment belief has widely spread around the world in past decades, dating back to protests against WTO in the late 1990s. During the early stage of activities driven by the theory, distrust of elites was often related to beliefs that the working class suffered from public policies designed by elite politicians, such as globalization, tax reforms, and immigration policies that they believe became harmful to their benefits, which indicates that at this stage the anti-establishment theory was correlated with political and economic discontent of the left-wing proletariat. However, this theory

started to be adopted by the far-right politicians and voters in the US during the Trump administration in the US. Several papers reveal that the Trump administration benefited from the far-right anti-establishment populism to win the 2016 Presidential Election and connived with far-right organizations and media (such as KKK, Proud Boys, and Fox News) to support the protest against elites (Uscinski et al., 2021; Gaufman, 2018). Brexit was also impacted by the anti-establishment theory. Osuna et al. (2019) claim that the Brexit narratives are correlated with an anti-establishment sentiment, and they find that voters in sampling areas shared a sense of pride in "sticking to Brexit decision" and a strong belief of "refusing elites to tell me what to do". Kellner (2017) examines Brexit, the result of 2016 US Presidential Election, and far-right parties in France (RN) and Germany (AfD) and demonstrates that Brexit was also influenced by right-wing anti-establishment beliefs that became extremely popular in the US and several other countries in the 2010s.

Additionally, there are also opinions claiming that the partisanship plays a significant role in political disputations on Brexit and the final result of the 2016 Referendum (Hobolt et al., 2021). However, this thesis is not designed to become a thesis on political research, thus any further discussions on political reasons for Brexit will not be provided.

2.1.4 Brexit: A Left-Behind Narrative?

Nevertheless, the political lens can still enlighten us to insert reasons for Brexit into a wider environment and combine Brexit with consequences of being politically and economically "left behind". Discussions on the left-behind regions have become popular in recent years. The leftbehind regions refer to majorly urbanised areas that experience economic decline, unsuccessful post-industrial developments, high unemployment rates, and lack of infrastructure. As is demonstrated in previous sections, pro-Brexit votes were centralised in Midlands, East of England, and in most cases, rural or left-behind areas. It is important to note that these regions have suffered from stagnated economic growth, high unemployment rates, failure of industrial transition, and low coverage of higher education. For example, Boston, where the highest share of pro-Brexit votes was recorded in the UK, has been impacted by low GDP growth rates, shrinking businesses, and a decreasing number of investments (Osuna et al., 2019).

In the UK, correlations between the pro-Brexit ideology and being economically left behind have drawn much attention in the academy. For instance, Rhodes et al. (2019) argue that the pro-Brexit belief resulted from the perception of being ignored due to economic stagnation in multiple remote areas in the UK, and post-Brexit condition seemed not to have eliminated the disadvantages of local development. Leyshon (2021) claims that uneven economic geography contributes to the development of Brexit narratives especially in left-behind places in the UK. Additionally, such narratives show significant hierarchical, spatial, and industrial heterogeneity. Hierarchically, Antonucci et al. (2017) find that pro-Brexit votes come from the majority of the middle class rather than the working class in most of left-behind regions in the UK, indicating that declining middle-class voters might have dominated the 2016 Referendum at least in leftbehind places. Spatially, Goodwin & Heath (2016) find that most of leaving votes come from industrialised, highly unemployed, and economically stagnated regions especially in Northeast and Southeast England. They also find that migrants from outside the UK, especially from the EU occupy an extremely small proportion in these regions, showing that the anti-immigration narrative seems to be popular in left-behind regions where migration hardly has any impact on local economic stagnation. Industrially, McCann et al. (2023) argue that overly centralised industries and ambiguous industrial policies result in the growing support for the argument that Brexit will help to reconstruct the UK's industrial policies and recover local industries in leftbehind regions.

In conclusion, numerous studies have noticed that Brexit and its relevant narratives might have correlated with being economically left behind in some UK regions, and heterogeneous impacts of Brexit on local economic growth in different left-behind places still deserve to be analysed. This thesis will provide a review study on whether Brexit contributed to improvements of industrial structures, reduction in unemployment, and overall economic recovery in left-behind regions in Wales and give empirical evidence to examine the hypothesis, i.e., Brexit has had positive impacts on local economic growth in left-behind regions in the UK and helped to solve economic, employment, and industrial difficulties.

2.2 Brexit and other Independence Movements

Fuelled by the growing populism in the past decades, we have witnessed various kinds of independence movements across the globe, and it will be of much help to analyse the similarities and differences between Brexit and these movements. There are several forms of independence movements.

First, the narrow definition of these movements refers to political activities aiming to achieve independent rights to control the territories, public policies, and economies of certain regions, and examples of them include the Catalan independence movement in Spain and the Scottish

independence movement in the UK (Crameri, 2015). It presents in a way that the existing governance of the superior administration has conflicts against local benefits, so regaining local sovereignty becomes necessary. According to this definition, Brexit can also be categorized as an independence movement with the objective of regaining the UK's sovereignty and independent decisions of public policy and eliminating the impacts of the EU on the UK's domestic policies, as is discussed in previous sections.

Second, numerous studies adopt a more generalised definition of independence movements and consider them as a significant branch of ideological and political isolationism (Dodson & Brooks, 2022; Galizzi, 2019). Politically, the independence movements are constructed based on distrust of elites and anti-establishment ideologies and dedicated to exiting certain political and economic coalitions, alliances, and organisations that are believed to erode sovereignty. For example, the US exited UNESCO since the Trump administration confirmed that becoming a member of UNESCO only brought heavy financial burdens to the US. During the same period, the US also withdrew from the Paris Agreement on climate change since the same administration believed that the existence of climate change was still debatable and several major CO2 emitting countries such as China failed to fulfil the promise of reducing the CO2 emission, which made the agreement unreliable.

On the basis of the existing literature on definitions and features of independence movements, we find several differences and similarities between Brexit and other major independence movements around the world.

1) Differences. First, country-level independence movements are a political motion that aims to establish a regional sovereignty from existing superior sovereign states (Crameri, 2015). For example, the Catalan Independence Movement seeks the sovereignty of Catalonia from Spain, and the Ryukyu Independence Movement is dedicated to the sovereignty of Okinawa Prefecture from Japan. Both Catalonia and Okinawa are political existences of existing sovereign countries, which indicates that their independence schemes are very unlikely to become realities due to administrative and legislative impacts of central governments on local affairs even though referendums can be organised. Second, Brexit is not a regional independence movement but a sovereign recontrol from an existing supranational political and economic union, i.e., the EU. The loose integration of the EU makes it impossible to impose administrative or legislative impacts on member states if some of them have decided to organise and second.

independence referendum to exit the EU (Lord, 2017). It can explain several attempts to leave the EU, such as "France Exiting the EU" (Frexit) and "Greece Exiting the EU" (Grexit), since the independence from the EU has fewer obstacles than that from a sovereign state.

- 2) Similarities. First, most of these movements are driven by right-wing ideologies such as isolationism and populism and promoted by right-wing political organisations such as the National Rally in France, Vox in Spain, and the Conservative Party in the UK. Second, the narrative that becoming a member of the superior political existence will undermine independent political and economic rights has encouraged these movements to be proceeded. Finally, several parties that support independence movements share the same anti-migration theory and believe that the international migration has negative impacts on the local employment and causes higher local unemployment rates, fierce employment competition, and lower income levels. For example, the RN in France has continuously opposed international migration, especially the migration from the middle east and the Islamic states. The incumbent president of the RN, Marine Le Pen, has repeated her motion to expel 3 million Islamic migrants and refugees if she becomes the President of France (Le Pen, 2016). Restricted to the centralised immigration policy of the EU, France also needs to exit the EU to establish an independent immigration system, according to the RN principles. Additionally, de-risking from China to protect domestic job opportunities and the security of industrial development has become another principle shared by the majority of right-wing parties in the EU (Jash, 2023).
- 3) Impacts of independence on international migration and economic growth. While the independence campaigns mentioned above have not resulted in actual independence of these regions, it can be noticed that after the independence from Malaysia, the number of migrants to Singapore increased rapidly and the GDP growth rate in this city-state has been greatly higher than its ex-suzerain (Huff, 1997). However, independence campaigns in Europe have not achieved expected impacts on inward migration. For instance, the number of numerous kinds of migrants to France including family members of both French citizens and foreign nationals, refugees, students, and workers increased steadily by 25% from 2010 to 2019, albeit aggressive claims of deportation promoted by the RN (See Figure 2.4). Mieriņa, & Koroļeva (2015) claim that rounds of independence campaigns and anti-migration threats in Europe are estimated to have little impacts on actual migration trends due to extremely difficult living environments in move-out regions and impossibility of far-right parties controlling Europe.



Figure 2.4 Number of migrants to France, 2000-2019

Source: Author's calculation based on census statistics from the French National Institute of Statistics and Economic Studies (INSEEE)

2.3 Conclusion

In this chapter, I first introduced the history of the UK joining and leaving the EU in the past few decades and focused on major economic and political reasons for such a significant conversion that might impact the UK economy for decades to come. Regaining economic sovereignty in migration, labour, and UK's industrial policies are among the most significant reasons. I specifically highlighted the role of the anti-migration theory in Brexit debates and connected it with the tradition of Euroscepticism in the UK. Correlations between pro-Brexit ideologies and perceptions of being economically neglected in left-behind regions of the UK were also reviewed. Second, Brexit shares a similar purpose, namely retaking the autonomy and independence of domestic policies, with several other economic and political campaigns such as the Catalan Independence Movement in Spain, far-right policies promoted by AfD in Germany and RN in France, and the theory of "America First" during the Trump administration. I found that the main difference is whether the concept of economic and political independence became reality, i.e., Brexit as an economic and political agenda led to actual leaving the EU after 2021 while similar Leaving-EU campaigns in France and Germany and Leaving-WTO campaigns in the Trump administration of the US did not succeed. These campaigns along with Brexit share several similarities, namely the anti-migration belief and attempts to protect domestic labour market, encourage domestic industries, and de-risk the domestic economic growth from threats of trade and security with China. Based on discussions above, I completed
the scene-setting procedure of Brexit and prepared for further literature review on impacts of Brexit on migration to the UK and the UK economy.

Chapter 3 Modelling Brexit: Migration and Growth

In this chapter, I focus on adequate and still increasing literatures of analysing impacts of Brexit on multiple socioeconomic dimensions in the UK. It is important to note that a multitude of articles, papers, and reports have emerged in the past decade, especially after 2016 when the referendum decided Brexit, which provides valuable references for my research. However, in accordance with the growing demand for reforms of immigration systems in the UK, levellingup strategies of the UK economy, and reconstruction of UK's international trade policies after Brexit, this thesis mainly discusses impacts of Brexit on migration to Wales and the Welsh economy as a part of analysing these impacts on migration to the UK and the UK economy, indicating that the literature review is majorly unidirectional and focuses on impacts of Brexit in Wales. Thus, this chapter aims to offer updated and comprehensive introduction to current literature on impacts of Brexit on several major economic factors in the UK. Section 3.1 introduces existing research on impacts of Brexit on migration to the UK, Section 3.2 includes review on analysing impacts of Brexit on GVA and local economic growth in the UK, and Section 3.3 focuses on investigating impacts of Brexit on trade between UK and its trade partners. In these three sections, I combine literature review with examination of models and methodologies applied in research of each section and deliver several hypotheses to be verified for each section. Section 3.4 demonstrates main approaches that have been applied to research on impacts of Brexit on the UK economy and migration. Section 3.5 gives a brief description of current literature on impacts of Brexit on migration to Wales and the Welsh economy, preparing for a more detailed review in following empirical Chapters 4, 5, and 6. Section 3.6 concludes this chapter.

3.1 Modelling Brexit 1: Impacts on Migration to the UK

3.1.1 Current Literature

Concerns over impacts of Brexit on migration from the rest of the world to the UK have led to a resurgence of academic attention since the beginning of Brexit debate in the early 2010s. Several scholars, such as Butler (2016), have claimed that the partisanship on the migration issue in the UK had a significant impact on the growing Brexit theory. For instance, particular concerns over the negative impacts of EC (the European Commission, the predecessor of the EU) membership on migration and the UK economy became a leverage between the Labour and Conservative parties, which led to the first Brexit attempt, the 1975 Referendum to decide whether the UK should leave the EC. Although the result of the 1975 Referendum decided the UK remaining in the EC, supports for Brexit due to fear of migration waves increased in both parties in past few decades. Politicians from the Labour Party believed that the EU membership contributed to migration waves to the UK, which had caused rising unemployment and inflation rates in the UK (Butler, 2016). Jeffery et al. (2016) also reveal that it gradually became the mainstream in the conservative party since 2010 that leaving the EU would bring back economic independence, immigration control, and a brighter future for the UK. However, it is hard to say that the Conservative party has been the dominant of the Brexit agenda since a considerable number of PMs in both parties support this agenda.

It is important to notice that the Euroscepticism, i.e., a belief that being an EU member will be harmful to the UK economy, contributed to the popularity of migration-related Brexit debates. The 1975 Referendum left the UK within the EC, but migration-related Euroscepticism became a strong feature of the UK political landscape and saw rapid growth after the development of the Single European Market, and the growth of the EU embracing countries in Central and Eastern Europe (Miller, 2015; Vasilopoulou, 2016). Taggart and Szczerbiak (2018) for example, claimed that Brexit was an expression of Euroscepticism was one factor leading to the 2016 Referendum which started the process of Brexit and with the final Brexit withdrawal agreement signed in January 2020, followed by a one-year transition period. According to this agreement, multiple restrictions were to be implemented on migration from EU countries to the UK, including universal rules of migration for migrants from the EU and the rest of the world, stricter and longer investigation processes, and the end of EU students being categorized as UK domestic students for the purposes of fees (Sumption and Kierans, 2021; Hantzsche et al., 2019).

Having discussed several reasons why migration matters in Brexit, we can witness a bulk of literature on impacts of Brexit on migration to the UK. More specifically, the current literature on this issue can be divided into several parts:

 Impacts on the number of migrants to the UK, based on countries of birth. As is shown in Table 3.1, EU citizens are now required to apply for UK worker visas regardless of their income levels due to the abolition of free movement rights across the UK and EU region before Brexit. Non-EU citizens applying for UK worker visas were required to earn at least £30,000 per annum for a graduate job with multiple additional conditions before Brexit; the new rules of migration policy after Brexit have made more middleskilled jobs qualified for applying for worker visas with the minimum salary being £30,000 per annum, much lower than the previous line. As demonstrated by Lee (1966), push factors are a set of unfavourable endowments that encourage out-migration from the origin country and pull factors are those that attract migration to the destination country, while additional restrictions on EU migrants can be considered as a push factor that discourages migration to the UK, though it is based in the destination country. The current literature has focused on how Brexit could impact the number of future migrants to the UK. For instance, Portes (2022) demonstrates that Brexit-related restrictions on migration would have considerable impacts on EU citizens who previously had free movement rights, while non-EU citizens would be less directly impacted by Brexit and could even benefit from a relatively more equal and the universal post-Brexit migration policy. He further provides an estimation of a decrease in net EU migrants of around 95,000 from 2022-2027 after the transition period, developed from another research conducted by Portes and Forte (2017) who provide a forecast of a decrease in net EU migration of between 91,000 (with a transition period) and 150,000 (without a transition period) from 2016-2020. Real migration data during this period revealed that their forecast was quite accurate. Dhingra et al. (2016) forecast a cut in EU migration to the UK of 80,000 per year in 5 years. Lisenkova & Sanchez-Martinez (2016) estimate a reduction of 70,000 per year in future net migration to the UK and the majority (76%) of this reduction is net migration from the EU. McConnon (2022) uses the spatial security and risk model to empirically forecast how EU citizens already living in the UK will be impacted by these migration restrictions and estimate that 12% of current EU citizens who are working in the UK will decide to move outside the UK. Outmigration patterns will not be analysed in this thesis since the available data shows that most direct impacts of Brexit-driven restrictions on migration are imposed among move-in migrants to the UK, which will be thoroughly discussed in the following chapters. Several economists raised the issue of out-migration indirectly encouraged by Brexit, but it is a complex topic which requires discussions in the future.

Table 3.1 Current Requirements for Labour Migration to the UK

≥ £30,000 per annum <£30,000 per annum

EU migrants	Point-based workers' visas required			
Non-EU migrants	Point-based workers' visas required	Not eligible		

Source: The 2016 Referendum result data published by The Electoral Commission.

- 2) Impacts on the number of migrants to the UK, based on industries. The Labour Force Survey data have shown that the proportion of migrants in different industries in the UK varies significantly¹⁷, with higher proportions in industries such as manufacturing and construction and lower proportions in industries such as administrative services. Given diverse features of migrants in different industries, it is also expected that Brexitrelated restrictions on immigration would have heterogenous impacts on migrants across these industries. Simionescu et al. (2017) predict that several industries having embraced the majority of migrants in the UK will experience a rapid decrease in the number of labour migrants and have to proceed with more recruitment activities to hire more local residents as employees, which might be helpful to solving the problem of high unemployment rates in certain regions. Regarding industries more specifically, for EU migrants, the UK's construction industry absorbed over 36% of total labour migrants from the EU region from 2010 to 2015 and is expected to hire 15% fewer EU migrants and 17% more local residents on average per year compared to pre-Brexit (Mohamed et al., 2017). The manufacturing industry in the UK is also expected to have a reduced number of EU labour migrants after Brexit. For migrants from non-EU areas, Byrne et al. (2020) demonstrate an increase in non-EU migrants in multiple industries such as education, financial services, and health services in the UK after Brexit, and also estimate a rising number of non-EU migrants especially from India and China in educational and financial sectors in the future.
- 3) *Impacts on migrants to the UK, based on skill levels*. One of the most important and debatable arguments that support Brexit is excessive migrants to the UK undermined the job opportunities for unskilled or lower-skilled local employees. Before Brexit, the access to labour through the scheme of free movement between the UK and EU has led to an underinvestment in the development of labour skills provided by companies in

¹⁷ See ONS Labour Force Survey official site: <u>https://www.ons.gov.uk/surveys/labourforcesurvey</u>

the UK (Teague & Donaghey, 2018). However, in several industries such as financial sectors, labour migrants from the rest of the world hold higher levels of educational attainment than their local counterparts (Alfano et al., 2016). The Labour Force Survey data has shown that the majority (62%) of EU migrants in the UK are unskilled or lower-skilled while the majority (72%) of non-EU migrants in the UK have mid or higher-level skills¹⁸. Vargas-Silva et al. (2019) attribute the difference of skillset distribution between EU and non-EU migrants in the UK to factors making migration to the UK easier such as shorter distances and closer cultural relationships between the EU and UK, lower working-visa requirements for EU citizens, and more fierce competition of applying for workers visas in non-EU countries such as China. More recently, for instance, Liu et al. (2022) provide a forecast of a rapid increase in the number of higher-skilled migrants from China to the UK, New Zealand, and some other developed countries due to high unemployment rates and economic depression in China. They also estimate that 78% of these potential migrants hold at least a bachelor's degree, 20% of them have a master's or higher degree, and 56% of them are already professionals. Considering major impacts of Brexit-related restrictions on EU migrants, Brinkley & Crowley (2017) estimate that the number of unskilled and lower-skilled EU labour migrants will decrease by 12% in five years after Brexit and also suggest that reduced access to EU migrants might result in a concentrated reinvestment in skill development. They estimate a 15% increase in the number of higher-skilled EU labour migrants who hold at least a bachelor's degree in the same period in the UK, showing more benefits of job opportunities for EU migrants with higher-level skills. For non-EU migrants, Peresman et al. (2023) illustrate that non-EU migrants with high-skill levels are estimated to continuously increase in the UK and impacts of Brexit on between low and high-skilled non-EU migrants to the UK are fundamentally distinct.

4) Future expectations of impacts on the migration to the UK. We have witnessed several external shocks since 2020, two of the most significant of which might be the Covid-19 pandemic since 2020 and the Ukrainian War since 2022. Harima (2022) illustrates that the Covid-19 pandemic has significantly discouraged international migration due to fear of being infected. Multiple studies have revealed that the severity of the Covid-19 pandemic in 2020 and 2021 in the UK contributed to the decrease in the willingness of migrating to the UK among EU migrants (Sargent, 2023; Walsh et al., 2022). Due to

¹⁸ See ONS Labour Force Survey official site: <u>https://www.ons.gov.uk/surveys/labourforcesurvey</u>

the paucity of relevant literature on a regional level, specific impacts of the pandemic on migration to post-Brexit UK countries (such as Wales) are still unclear. Meanwhile, after the post-pandemic became a "new normal" and negative impact of the pandemic on the society gradually perished, the Russian Invasion of Ukraine is expected to boost migration from Ukraine and its neighbouring countries to the western Europe, and the UK is believed to be one of the most important migration destinations, thanks to the superior economic and welfare conditions (Mbah & Wasum, 2022; Machin, 2023).

3.1.2 Hypotheses

On the basis of discussions above, it is feasible to raise main hypotheses regarding impacts of Brexit on migration to the UK by taking Wales as an example. As a UK country, Wales shares the majority of migration patterns with the UK national trends and deserves more empirical analysis on impacts of Brexit of inward migration given the insufficient literature. Meanwhile, Wales keeps economic and labour connections with the EU region and has become one of the most important migration destinations for EU migrants. Thus, with regard to such impacts on a UK-country level, we have hypotheses as follows:

- Migration from outside the UK to Wales has been impacted by Brexit-related migration policy shocks.
- Such impacts are heterogeneous between EU and non-EU groups of migrants, among different industries, and migrants with different income levels.
- 3) Such impacts might last for a long period, combined with impacts of recent shocks, i.e., the pandemic and the Ukrainian War, and heterogeneity based on industries, countries of birth, and income levels remains significant in the future.

3.2 Modelling Brexit 2: Impacts on the UK Economy

3.2.1 Current Literature

A multitude of current literature concentrates on reviewing causal effects of Brexit on macrolevel economic growth in UK and estimating future impacts of Brexit on the UK economy. Numerous organizations have already released various estimations regarding the potential long-term economic impacts of Brexit on the United Kingdom. These assessments include two reports provided by the UK government: one formally published by the Treasury prior to the 2016 Referendum¹⁹, and an initial version of government analysis that surfaced in January 2018²⁰. Figure 3.1 summarises the majority of existing studies on measuring impacts of Brexit on the UK economy by both researchers and the private sector and most of them claim that Brexit will have negative impacts on economic growths in the UK, although the scale of such impacts varies across different studies. Among these 15 representative studies, only a study provided by the Economists for Free Trade (EFT) claims that the UK economy can be significantly boosted by Brexit (Bootle et al., 2017). Most of these studies consider different international trade schemes between the UK and its trade partners as a core baseline upon which impacts of Brexit on the UK economy will vary. In most cases, negative impacts of Brexit on the UK economy are estimated to be the worst if the UK has to renegotiate with trade partners individually based on regulations of the World Trade Organisation. Such impacts are expected to be reduced to a minimum if the UK can still have free-trade agreements with EU countries. To summarise, both academies and business industries believe that Brexit will have negative effects on the economic growth in the UK, compared to remaining in the EU previously.

¹⁹ HM Treasury and Osborne G., The Immediate Economic Impact of Leaving the EU, Cm 9292, 23 May 2016, retrieved 2 October 2017: <u>https://www.gov.uk/government/publications/hm-treasury-analysis-the-immediate-economic-impact-of-leaving-the-eu</u>

²⁰ House of Commons Exiting the European Union Committee, EU Exit Analysis: the Cross Whitehall Briefing, January 2018: <u>https://www.parliament.uk/globalassets/documents/commons-committees/Exiting-the-European-Union/17-19/Cross-Whitehall-briefing.pdf</u>



Figure 3.1 Forecast of long-term impacts of Brexit on UK's GDP relative to remaining in the EU

Notes: CEP: Centre for Economic Performance, CPB: Netherlands Bureau for Economic Policy Analysis, EFT: Economists for Free Trade, HMG: HM Government, NIESR: National Institute of Economic and Social Research, OE: Open Europe, Oxford: Oxford Economy, Rabobank: Robobank Group, Treasury: HM Treasury, Rand: Rand Corporation, PwC: PwC Consulting UK, Ciuriak: Ciuriak Consulting, Bertelsmann: Bertelsmann SE & Co., OE: OE Consulting. Source: Institute for Government Analysis.

The initial estimates of Brexit's long-term consequences may conceal variations among different types of businesses, geographical regions, and individuals with varying income levels. Most of the economic models used to forecast Brexit's overall impact on the UK economy lack the capability to examine these finer details. Nevertheless, these distributional questions are likely to pique the interest of MPs, aiding their comprehension of how any proposed deal might impact their respective constituencies. In an effort to address these questions, several economists have attempted to extrapolate distributional implications using insights drawn from comprehensive economic models (Mohamed et al., 2017; Davies & Studnicka, 2018). These analyses suggest that certain sectors, such as clothing manufacturing and high-tech industries like aerospace, will experience significant repercussions due to their heavy reliance on imports from and exports to the EU.

When considering the impact on income distribution, most of the published analyses thus far indicate that all income groups will face a similar level of adversity from any negative consequences of Brexit (Bloom et al., 2019; Pollard, 2021). Lower-income households are expected to be more negatively affected by rising commodity prices, particularly for food prices. In contrast, higher-income households are likely to experience adverse effects through reduced wages, as they are more inclined to work for export-oriented businesses. Discussions on impacts of Brexit on the UK economy through the mechanism of income levels in this thesis

will consider more direct impacts of Brexit on migration to the UK, which is mentioned in previous sections, to form a comprehensive picture of macro-level influences of Brexit.

More specifically, we have concluded that macro-level impacts of Brexit on the UK economy can be implemented through the following mechanisms:

- (1) *Trade.* Although detailed introductions of current literature on impacts of international trade of the UK will be provided in following sections, here we would like to offer a big picture of major findings with regard to this issue. Dhingra et al. (2016) estimate that Brexit will lower trade between the UK and the EU due to higher tariffs and the main economic benefit of leaving the EU is a lower net contribution to the EU budget. They also forecast that a loss of 6.3% to 9.5% of UK's GDP will happen due to lower productivity driven by reduced trade with the EU. Brakman et al. (2018) establish two scenarios, i.e., no-transition-period "hard Brexit" and transition-period Brexit and estimate significantly negative impacts of Brexit on international trade for the UK in both scenarios. Given that we have experienced the one-year transition period in 2020, it is more likely that estimations of the latter scenario better conform to the actual data of international trade.
- (2) FDI. The UK remains one of the most significant destinations of foreign direct investment due to its business-friendly environments and advanced financial services. FDI is believed to benefit nations since it can result in the development of new sectors, industrial transformation of existing ones, the distribution of innovations, and the maintenance of economic growth (Tsai, 1994). Khan (2023) examines the decreasing FDI in the UK after Brexit and claims that Brexit has had a major depressing impact on growth in the UK economy through the mechanism of discouraging FDI. Ellalee & Alali (2023) adopt the Markov regime switching model to investigate impacts of Brexit on FDI in the UK and find that Brexit will lead to a depreciation of the pound sterling in the current economic ambience, which results in a long-term negative impact on FDI. McGrattan and Waddle (2020) more prudentially claim that impacts of Brexit on FDI in the UK largely depend on different scenarios of UK's trade policies, outcomes of free-trade negotiations between the UK and its trade partners, and where the UK will ease domestic restrictions on FDI previously required by the EU single market.
- (3) Exchange rates. The value of the pound sterling is a measure of the economic strength and stability in the UK. The 2016 Referendum is believed to have caused a depreciation of the British pound against the euro and the US dollar in 2016 and 2017 (Korus &

Celebi, 2019), indicating that the financial sector was concerned about depreciation shocks driven by Brexit. Fluctuations in exchange rates can normally have following impacts on the UK economy. First, the deterioration of sterling can raise the price of imports and reduce the price of exports, which encourages exports and discourages imports. Existing literature has claimed that Brexit can depress import due to fluctuations in pound sterling. For instance, Bernanke & Mihov (1998) find that import can be depressed by policy shocks due to negative perception of potential future uncertainty, negative impacts of policy shocks on domestic corporate productivity, and chances of domestic producers being replaced by foreign producers in the global market. For the case of Brexit, these findings are consistent with future risk estimation, negatively impacted productivity, and less competitive local firms in the UK due to Brexit, which are justified by given literature in this chapter. Discussions on this issue need to be inserted in analysis of impacts of Brexit on international trade, as is mentioned above. Second, estimations of short-term sterling depreciation will attract more FDI while estimations of long-term sterling depreciation will result in negative expectations of investment to the UK. Third, the depreciation shock normally results in higher inflation and Breinlich et al. (2022) find that the sterling depreciation contributed to the increase in consumer prices by 2.9% due to higher costs of imports. Other external shocks such as the Covid-19 pandemic and the Ukrainian War might have influenced the UK's inflation, which needs to be decomposed in the following analysis.

(4) Corporate TFP. From firm-level perspectives, corporate TFP represent individual productivity of firms and can have significant impacts on overall economic growths and stability. Bloom et al. (2019) demonstrate that Brexit is estimated to have reduced corporate TFP in the UK by between 2% and 5% over three years after the 2016 Referendum and the main reason for this drop is negative within-firm effects, i.e., firms committed hours per week of management to Brexit-related reschedule of business. Fingleton et al. (2023) examine the regional heterogeneity in impacts of Brexit on corporate TFP across the UK and find that regions with less business connection with EU countries witnessed less reduction in corporate TFP due to Brexit, compared to other UK regions with more business connection with the EU single market. Some other scholars focus on impacts of Brexit on corporate TFP through the lens of labour productivity. For instance, Farid (2020) demonstrates that Brexit had negative impacts on labour productivity, causing GDP per hour worked to decrease by an average of 2.24% per year and aggregate GDP created by firms to decrease by 2.15%, compared to

remaining in the EU. However, discussions over industrial and regional heterogeneity in firm-level impacts of Brexit on corporate TFP are still inadequate, which is another objective of this thesis.

3.2.2 Hypotheses

Based on discussions above, this thesis aims to examine impacts of Brexit on the UK economy from several aspects by taking the Welsh economy as an example. The Welsh economy is a significant component of the UK economy, which not only shares multiple features such as the dominant tertiary sector but also owns its unique characteristics such as the cornerstone of manufacturing industry. Brexit might have imposed similar impacts on the Welsh economy as it did on the UK economy as a whole but will also reflect Wales-specific identities in different industries. Thus, with regard to such impacts on a UK-country level, we have major research questions as follows:

- (1) Considering that Wales shares close trade contacts with the EU region, did Brexit impose causal effects on changes in imports and exports between Wales and its trade partners, especially between Wales and EU countries? Based on the existence of such causal effects, how will Brexit have long-term effects on international trade for Wales?
- (2) Wales has been a significant FDI location in the UK. Can Brexit explain changes in FDI in Wales and to what extent did different industries in Wales receive heterogeneous impacts from Brexit? Will such impacts continue or vanish in the future?
- (3) Local businesses, especially SMEs, have been an important driver to boost the Welsh economy. Did Brexit impact corporate TFPs for firms in Wales through mechanisms of exchange rates, inflation, and labour productivity? Will such impacts be combined with other external shocks, namely the Covid-19 pandemic and the Ukrainian War?

3.3 Modelling Brexit 3: Trade as a Mechanism

3.3.1 Current Literature

International trade has played a significant role in the Welsh economy and numerous studies have revealed that Brexit will majorly impose impacts on international trade especially between the UK and EU. Thus, international trade might be considered as an important mechanism through which Brexit will affect the broader Welsh economy. Benefiting from updated data of international trade between the UK and its trade partners, numerous studies have been conducted and provided in-depth review analysis on this issue. For instance, regarding the

overall trend of international trade for the UK, Du et al. (2023) apply the synthetic DID (difference-in-difference) method to build a counterfactual UK economy that remained trade deals with the EU as before Brexit and find that negative, large, and statistically significant impacts of the new UK-EU trade deal, i.e., the EU-UK Trade and Cooperation Agreement (TCA) on UK exports have persisted over the sample period (2019 to 2022Q1). They also find that imports and exports between the UK and its non-EU trade partners seem not to have been significantly impacted by Brexit. Trade between the UK and the EU is also believed to have been disturbed by Brexit due to the lost imported varieties produced by high productive European firms (Latorre et al., 2020).

More specifically, there are two dimensions of impacts of Brexit on international trade for the UK:

(1) Regions of trade partners. Considering that additional restrictions have been imposed on trade between the UK and EU countries, a multitude of economists estimate that imports from the EU and exports to the EU will suffer from Brexit-related trade policies more severely than those between the UK and non-EU trade partners (Thissen et al., 2020; Buigut & Kapar, 2023), showing the regional heterogeneity in trade with various counterparts. Regarding the UK-EU trade, for instance, Buigut & Kapar (2023) adopt a gravity model and illustrate that the Brexit referendum phase (2016-2020) depressed UK-EU trade by around 10.5% and the transition phase (2020-2021) by around 15%. They also find that during the transition phase, negative impacts of Brexit on imports from EU were greater than exports to EU, suggesting some EU trade previously with the UK was redirected to other EU members. Meanwhile, ONS data shows that among top 10 UK's import and export markets, only two countries are outside the EU, i.e., the US and China²¹. Regarding the UK-US trade, although few studies estimate impacts of Brexit on changes in actual UK-US trade, Khorana and Kerr (2023) claim that the US-UK new trade agreement faces the dilemma of long-term negotiations and there is no trade agreement between two countries²². A number of scholars such as Freeman et al. (2022), however, estimate that the UK-US trade will not be significantly influenced by Brexit due to stability of demand for US imports in the UK. Regarding the UK-China trade, comparatively, the current literature is much more adequate than research on the

 ²¹ See series of ONS dataset of UK total trade: all countries, seasonally adjusted, last release date 27 July 2023: https://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/datasets/uktotaltradeallcountriesseasonallyadjusted
 ²² See UK Parliament Research Briefing: https://commonslibrary.parliament.uk/research-briefings/cbp-9314/

UK-US trade. Xiong (2022) predicts that Brexit will have positive impacts on the UK-China trade due to opportunities of expanding categories of trade products between the two countries under a potential UK-China trade agreement albeit the current "decoupling" campaign. Kostecka-Tomaszewska & Krukowska (2023) claim that although the trade intensity between the UK and China was lowest compared with Germany and the US in 2012-2022, the position of China in the UK's international trade strategy has been increasing and there is potential to increase exports to China. To summarize, the majority of current literature shows that Brexit discourages both exports to the EU and imports from the EU but might boost imports from non-EU countries such as the US and China.

(2) Industries. The UK has been considered as an important hub of international trade with dominant services trade and various kinds of tradable goods belonging to different industries (Borchert, 2016). Spital and van Aerssen (2023) claim that Brexit leads to a significant decrease in UK goods trading volumes with the EU, which is below the prepandemic level and the average level of UK goods trading volumes with non-EU countries. Meanwhile, they find that services trade with the EU did not receive significant impacts from Brexit but was significantly disturbed by the pandemic, while services trade with non-EU countries was not significantly impacted by either Brexit or the pandemic. Regarding industrial heterogeneity, Ayele et al. (2021) claim that several industries in the UK such as manufacturing, education, and retailing services will suffer more from negative impacts of Brexit on trade compared to other industries due to highlevel trade communications between the UK and EU in these industries. Nevertheless, different UK regions such as Scotland and Wales have extremely different industrial features and various levels of interactions with the EU single market, indicating that impacts of Brexit on trade in different industries can be regionally heterogeneous and remain to be further investigated.

3.3.2 Hypotheses

Following discussions above, the following hypotheses are examined to enable a better understanding of impacts of Brexit on trade between Wales and its counterparts, given that Wales keeps frequent and a large number of trade volumes with both EU and non-EU trade partners.

- (1) How did Brexit impose heterogeneous impacts on international trade between Wales and its trade partners by nationality of them, i.e., through which mechanisms? And how will such impacts develop in the future combined with other external shocks?
- (2) How did Brexit impose heterogeneous impacts on international trade between Wales and its trade partners by industry, i.e., through which mechanisms? And how will such impacts develop in the future combined with other external shocks?

3.4 Main Approaches

This section includes introduction and discussion of several potential approaches to analysing impacts of Brexit on migration and economic growth in the UK, namely the risk perception approach to examine impacts of Brexit-related uncertainty, the gravity model to analyse the migration response to Brexit, and the DSGE method to establish an open economy framework in the context of Brexit. It is then followed by specific introduction of analysis on the nexus of Brexit and the Welsh economy and the Wales-based perspectives of Brexit research.

3.4.1 Risk Perception Approach

There are numerous studies modelling the impacts of Brexit on migration and economic growth in the UK. According to the UK-EU agreement on Brexit, which was in effect since 1st January 2021, any free movement for EU citizens (except Irish citizens) to the UK has been prohibited and is replaced by the points-based immigration system which has already been conducted for immigrants from non-EU countries (European Union, 2019). Thus, non-EU immigrants will not be affected by Brexit at all, while EU immigrants will suffer from changes in UK immigration policies and might reconsider their decisions of moving to the UK. Dhingra et al. (2018) examined the history of UK-EU migrations and found that immigration from the EU to UK without any limitations helped millions of EU immigrants to work and live in the UK. Data also shows that the number of EU immigrants estimated to be living in the UK exceeded that of non-EU immigrants in 2012 and reached about 3.7 million with non-EU immigrants from EU countries will cause drastic amendments and changes in UK immigration policies and prospective trends of EU immigration to the UK (Currie, 2016).

Literature focusing on results of sudden changes in political, regional, or economic situations and perceptions of these changes on migration decisions are more and more frequent in recent years, while unexpected incidents (also called "black swan events") happened several times since 2016, such as the result of 2016 Presidential Election of the United States and the 2016 Brexit referendum. Brexit could be considered a quasi-natural experiment which provides risks and uncertainty of immigration. The following part will mainly discuss how Brexit will have influences on immigration using the uncertainty and risk perceptions approach.

Williams et al. (2012) used theoretical perspectives to figure out the correlations between uncertainty perceptions and migration and found that most immigration behaviours are risk averse since political or economic disadvantages in regions of origin would impose more risks on immigrants if they do not move out. However, some behavioural economists have found that not all rational immigrants dislike risks. For example, Jaeger et al. (2010) conducted empirical studies on domestic migration in Germany and found that risk-appetite citizens were more likely to take risks of migration and then, to migrate. In China, multiple researchers also found that risk averse household members were less likely to take interprovincial migration in some regions of China, and most of rural-to-urban migrants were risk appetite (Dustmann et al., 2017; Chen et al., 2010).

This contradiction could probably be explained with the utility theory for decision making. Immigration is an extremely important decision for citizens, which follows the principle of individual utility maximisation (Fishburn, 1968). Individuals who consider about their decisions of immigration would compare the expected utility of living in the country of birth with the expected utility of living in the destination country, which covers various social and economic aspects (e.g., Pellegrini and Fotheringham, 2002). Thus, according to the mental accounting theory developed by economist Richard H. Thaler, any perspective risks and uncertainty will become "discounts" on the expected value of utility and encourage or discourage immigration (Thaler, 1999). More specifically, according to the Prospect Theory, such "discounts" could be subjectively different from each other, even though the real amounts of them are equal (McDermott et al., 2008). Czaika (2015) used data of bilateral migrations between 26 EU countries and Germany and found that a negative expectation of economic growths and labour markets in the country of birth would have greater impacts on decisions of migration than an identical positive expectation in the destination country. Barrell et al. (2010) analysed the migration prospects of immigrants from 8 EU countries after the 2004 EU enlargement to the UK and claimed that an extremely negative prediction of local economic growths and political environments in countries of birth rather than a positive expectation of economic growths in the UK made them migrate to UK.

3.4.2 Gravity Model

In past decades, gravity models have been popular in capturing economic phenomena with regard to the movement of goods, services, and people. The gravity model of migration, originated from the gravity model of international trade and first developed by Railley (1931) who analysed the market concentration of the retailing industry, has become one of the most important methodologies in various studies on determinants of migration decisions. Beine et al. (2016) claim that the gravity model of migration reveals the agglomeration effect of regional economic growth in their case of international migration and is highly consistent with the Push-Pull theory which indicates that better supply attracts more inward migration and higher risks encourages outward migration. Numerous current literatures have adopted this model to review and forecast trends of migration by differentiating impact factors of migration in both moveout regions and move-in destinations. Karemera et al. (2020) utilize the gravity model to examine major determinants of migration to North America and find that the more the population of the move-out country has and the higher the income level in the destination country reaches, the more migrants will be observed. In China, inter-provincial migration is expected to be significantly impacted by the heterogeneous spatial economic growths across China's provinces and cities, and the concentration of migration is detected in economic centres such as Shanghai and Hong Kong (Zhang et al., 2020).

There are also a number of studies on impacts of Brexit on migration to the UK based on the gravity model of migration. Campos & Timini (2019) estimate that EU migrants to the UK will experience an inevitable decrease due to Brexit-related restrictions on EU migration as a negative factor that discourages migration while non-EU migrants to the UK might also adopt a wait-and-see attitude, based on expectations of UK's weaker economic positions and more uncertainties after Brexit. Gudgin et al. (2017) claim that major pull factors of migration to the UK include higher income levels, more job opportunities, better healthcare services, and inclusive educational resources, which will remain the same as before Brexit compared to move-out regions, so decrease in the number of migrants to the UK due to Brexit will be very minor. More specifically, the heterogeneity of impacts of Brexit on different groups of labour migrants in the UK has been examined by the cross-sectional gravity model, and two groups, namely EU migrants and all migrants in the agricultural and manufacturing industries are estimated to suffer the most from Brexit-related migration restrictions (Auer & Tetlow, 2023).

3.4.3 DSGE Model

Broader analysis on impacts of Brexit on macroeconomic variables such as GVA and trade has benefited from the DSGE model (aggregate or spatial versions), and several empirical studies adopted the New Keynesian approach of DSGE model. Originally, the DSGE model is used to examine how external shocks (especially monetary shocks) will have impacts on certain economic variables given the time-series condition in open economies. Discussions on using the DSGE model to measure impacts of Brexit on economic growth in the UK have also grown while Brexit has been considered a shock externally imposed on the UK economy.

Pisani & Caffarelli (2018) measure impacts of Brexit on international trade between UK and its trade partners based on a New Keynesian DSGE model and divide the UK economy into final and intermediate goods and services. They find that: 1) if there are additional tariffs after Brexit, UK exports will be reduced; 2) if tariffs on imports from both EU and non-EU countries do not increase, the macroeconomic costs of trade renegotiation for the UK can be reduced; 3) Brexit has an overall negative but limited impacts on the economic activity in the EU. Driffield & Karoglou (2019) also model impacts of Brexit on FDI in the UK based on a DSGE model and a Markov regime switching structural VAR method to differentiate between stable and volatile states of the economy. They find that FDI will only decrease if Brexit is combined with a sterling depreciation and leads to a highly volatile UK economy, which is rather unlikely.

3.5 Wales-based Perspectives of Brexit Impacts

Multiple research projects of how changes in migration will impact regional economic growths in Wales after Brexit have been conducted by Wales Centre for Public Policy (WCPP) and other academic and professional organizations. Relevant literatures will be discussed in following three parts: impacts of migration on economic growth in Wales before Brexit, estimated impacts of Brexit on migration waves to Wales after Brexit, and projected changes in regional economic growth driven by changes in migration waves due to Brexit.

First, some projects focus on the role of migration in economic growth in Wales before Brexit and have highlighted the importance of migration on aggregate productivity. For example, Crawley (2013) analysed the historical data of migration and macroeconomic factors and found that migration to Wales contributed to a growing Welsh labour market and a sizeable economic boost for Wales. In addition, the migration inflow did not increase the unemployment rate in Wales since labour migrants often work in sectors with a great number of hard-to-fill vacancies. More specifically, regarding different industries, labour migrants helped industries of construction, transportation, and communications to achieve higher levels of productivity and average wage, but also caused pressure on wage increase for service industry due to greater competition among employees. Overall, the impacts of migration to Wales on Welsh economy have been positive before Brexit.

Second, regarding to impacts of Brexit on migration after Brexit, Portes and Forte (2019) used two dimensions to divide labour migrants in UK into four categories: EU or non-EU migrants, annual earnings of less or more than £30,000. They have found that EU migrants earning less than £30,000 will immediately lose the right of applying for Tier 2 visa and will be the group most directly impacted. EU migrants earning more than £30,000 will not be as seriously impacted by Brexit as the first category, but they will still face higher opportunity costs and stricter migration policies. Non-EU migrants earning less than £30,000 have no rights to work in UK under the current policy, so that they will not be affected by Brexit-related restrictions on migration. Non-EU migrants earning more than £30,000 might increase after Brexit since they will benefit from more vacancies and types of working visa such as the global talent visa announced in June 2022.

Using these categories, they analysed the historical data of labour migration in UK and Wales and found that 17.4% of UK full-time employees were migrants in 2018 while the proportion in Wales was 7.5%. However, the proportion of EU migrants earning less than £30,000 in Wales among all labour migrants was 25% higher than UK average, and the proportion of non-EU migrants in Wales was 46% lower than UK average. Finally, they estimated that the end of free movement from EU to UK driven by Brexit would lead to greater reduction in migration in Wales compared to UK average (See Table 3.2).

		Net migration (no policy change)	Change over 10 years (%)	Change over 10 years (numbers)	Median Yearly Earnings (£)
United Kingdom					
	EU <£30k	643,897.8	-75%	-482,923	19,188
	EU >=£30k	231,249.6	-50%	-115,625	42,016
	ROW <£30k	249,267.5	0	0	19,916
	ROW >=£30k	226,206	20%	45,241	44,980
	Total	1,350,620.9	-41%	-553,307	
Wales					
	EU <£30k	19,317	-75%	-14,488	18,460
	EU >=£30k	6,786.8	-50%	-3,393	40,092
	ROW <£30k	2,801.75	0	0	21,008
	ROW >=£30k	1,872.75	20%	375	42,016
	Total	30,778.3	-57%	-17,507	

Table 3.2 Estimation of net migration changes after Brexit

Sources: Labour Force Survey, calculated by Portes and Forte (2019).

Lastly, regarding the issue of how such changes in migration patterns would impact regional economic growth in Wales, they also estimated that GDP of Wales would be hit by roughly 1 to 1.5% over next decade, compared to 1.5 to 2% for UK average during the same period. The fiscal position in Wales would also be impacted by this external shock on GDP since IFS estimates that a 1% decrease in long-term GDP leads to reduction in government revenue by roughly 0.4%. Hunt et al. (2016) also projected a 2% of negative impacts on GVA in Wales after Brexit in 10-year period. Besides total productivity, they also estimated that the demand for middle and low-skill labour migrants would decrease by 1.8%, and Welsh exports and imports would decrease by 0.8% during this period in Wales.

In summary, there are several research gaps in existing literature on impacts of Brexit on migration to Wales and the Welsh economy: (1) current studies mainly adopt macro-level data and methodologies to analyse these impacts, while firm and individual-level evidence is also essential to establish a solid foundation for a big picture of Brexit impact analysis. (2) these studies also suffer from lack of latest data and fail to discuss potential mechanisms through which migration to Wales (and the UK) responds to Brexit. (3) due to extremely insufficient literature in last three years, potential impacts of the Covid-19 pandemic and the Ukrainian War on migration to Wales and the Welsh economy have not been examined. I aim to fill these gaps by conducting a series of empirical studies in following chapters.

3.6 Conclusion

In this chapter, I review the existing literature on impacts of Brexit on migration to the UK, GVA and regional economic growth in the UK, and trade between the UK and its trade partners. I also introduce several methodologies to model the impacts of Brexit on migration to the UK and economic growth in the UK. According to the existing literature, Brexit is widely considered to have significant impacts on discouraging migration to the UK, especially the EU migration, and the trade between the UK and EU has been negatively impacted by Brexit. Meanwhile, several studies reveal that the renegotiation of trade deals after the Brexit have caused additional business costs for firms in the UK. The current literature presents numerous models to analyse such impacts with both micro and macro-level methods. For instance, the improved spatial models have been utilized in estimating impacts of Brexit on international migration to the UK and the DSGE model is used to analyse how Brexit can be inserted into the impulse-response settings to forecast its impacts on international trade and long-term

economic growth in the UK. To examine the causal effects of Brexit on multiple economic variables such as migration and trade, the DID method is another popular tool that has been applied to numerous Brexit-related empirical studies recently. To summarise, I demonstrate the major theories and empirical research on economic impacts of Brexit in the UK, which will be further supplemented in following chapters with Wales-specific narratives and analysis.

Chapter 4 Impacts of Brexit on Migration to Wales

4.1 Literature Review

4.1.1 Background and Motivations

As is discussed in previous chapters, there is particular interest in how Brexit, and resulting restrictions on immigration, could impact the decisions of those coming from the EU and the rest of the world to the UK. While research has been undertaken on these themes, rather less work has focused on the impacts of Brexit on migration into UK countries, with some expectation that some parts of the national economy would be harder hit than others by restrictions arising from the Brexit process. It is important to note that regional heterogeneity of impacts of Brexit on inward migration across UK countries might lead to various results of such impacts in a form of diverse patterns of migration, indicating the significance of regional, or more specifically, UK subnational research on how inward migration to the UK responded to Brexit and how future migration to the UK will be influenced by long-term effects of Brexit.

Each country consists of economically heterogeneous regions with highly different features of local economic growth and migration patterns domestically and internationally. In the UK, with regard to Brexit-related restrictions on inward migration, distances, local cultures, trade, and several other variables contribute to highly divergent pull factors that attract inward migration patterns has been proven to be of great value to empirical spatial analysis on migration in many regions (Rogers, 1967; Kaur, 2010). For instance, Markaki & Longhi (2013) demonstrate that different regions inside EU countries have shown regional heterogeneity of industrial structures, which results in extremely different demographic patterns of inward migrants across the EU. However, few empirical studies have focused on how migration to the UK on a subnational level would respond to Brexit in the future despite the bulk of research on impacts of Brexit on migration. More precisely, Wales, a UK country (subnation) which shares one of the strongest economic ties with the EU region has not been thoroughly examined regarding the issue of

migration and Brexit while migration decisions are more likely to happen between two regions with strong economic interactions and migration from the EU to UK is estimated to be most fiercely impacted (Renkow & Hoover, 2000).

In terms of the economic relationship between Wales and the EU, according to the trade data by ONS²³, both export values from Wales to the EU and import values from the EU to Wales have ranked 1st in total values of Welsh imports and exports with proportions (52%) remarkably higher than any other trade partners (for example, US-15% and China-18%) since the 2010s. Migration data published by the Welsh Government²⁴ show that EU migrants occupy more than 50% of total migrants to Wales, which is higher than the UK average of 36% from 2010 to 2020. The close economic and migration-based relationship between Wales and the EU region reveals the significance of conducting more empirical studies on impacts of Brexit on migration, especially from the EU region to Wales. Such research is an important step in analysing the regional heterogeneity that could trigger different regional responses to the impacts of Brexit (Figus et al., 2018; Gawlewicz & Sotkasiira, 2020). From the perspective of the demand for socioeconomic developments in Wales, the Welsh government also shows willingness and ambition of developing a Welsh version of balanced and forward-looking migration policies to benefit from inward migration in the future (Welsh Government, 2018), which indicates the necessity of subnational studies on this topic.

Following Portes (2022), this study adopts a Wales-specific lens to explore how Brexit has impacted migration to Wales and how such interactions will develop in the near future. Benefiting from the latest data, this chapter aims to decompose impacts of Brexit on migration to Wales into two dimensions: regions of origin (EU or non-EU regions) and income levels (higher or lower than £30,000 per annum). Following data updates, both review and forecast sections in this chapter include two new factors: the Covid-19 pandemic and the 2022 Russian Invasion of Ukraine. Several studies claim that the pandemic led to a sharp reversal of migration flows to the UK and will have mixed effects on future migration from EU countries to the UK (O'Conner and Portes, 2021; Sumption, 2021). Concerns over the perpetuation of the Ukrainian War starting in February 2022 have also generated academic focus on how migration flow from the EU region to the UK (Coleman, 2022; Sow, 2022).

²³ https://www.ons.gov.uk/businessindustryandtrade/internationaltrade

²⁴ See the website of Welsh Government: <u>https://www.gov.wales/migration-statistics</u>

Therefore, this chapter aims to make contributions to the current literature in following aspects. First, it performs a historical review of impacts of Brexit on migration from the rest of the world to Wales, which we believe is the first attempt to analyse such impacts from a subnational perspective in the UK. Second, benefiting from the latest data, this chapter also provides a fiveyear forecast for migration to Wales by considering more recent events that might influence future migration flows, namely the Covid-19 pandemic and the Ukrainian War.

4.1.2 Migration to the UK and Wales

Data has illustrated that Brexit has brought significant changes in migration to the UK and Wales from both EU and non-EU countries. Here we introduce a taxonomy to divide the whole Brexit period into several periods: before 2016, 2016-2020, 2020 until 2022. The reason for such division is that the 2016 Referendum is considered to have imposed negative perceptual impacts on migration decisions to the UK and economic activities in the UK, such as declining intention of migrating to the UK, investing and business expansion in the UK. Based on this taxonomy, it will be possible to give a big picture of how Brexit changed migration to the UK and Wales.

4.1.2.1 Current Patterns of Migration to the UK

International migration has formed an essential component of the population both in the UK and Wales. The UK has become one of the most popular migration destinations in the world and has witnessed rapid growth in the number of migrants since the 2000s. The latest data of migration has shown similar patterns. In 2022, the long-term migration to the UK was an estimated 1.2 million with an increase of 221,000 compared with 2021 (942,000), which was majorly fuelled by non-EU migrants who accounted for an estimated 80% of total migration²⁵. The number of non-EU migrants increased by 45% in 2022 compared to the data in 2021, due to people arriving in the UK for work-related reasons and protection. Migration waves seeking for security, protection, and job opportunities from Ukraine and Hong Kong might contribute to the considerable increase in non-EU migrants to the past year but the growth in non-EU migrants slowed over recent quarters. EU migrants to the UK accounted for 13% of total immigration in 2022, notably lower than 52% and 42% in pre-pandemic 2018 and 2019, respectively. Figure 4.1 shows quarterly patterns of migration to the UK from 2018 to 2022

²⁵ <u>https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/internationalmigration</u>

and demonstrates that the number of EU migrants experienced a successive decrease during this period while the number of non-EU migrants doubled in four years.



Figure 4.1 Number of non-EU, EU, and British nationals migrating to the UK, 2018-2022

Notes: YE refers to year ending. Non-EU figures are based on Home Office Borders and Immigration data, EU figures are based on Registration and Population Interaction Database (RAPID) data received from Department for Work and Pensions and HM Revenue and Customs, and British nationals figures are based on the International Passenger Survey (IPS). Source: Office for National Statistics, Department for Work and Pensions, Home Office.

4.1.2.2 Migration to the UK: Historical Trends

Historically, Figure 4.2 shows the population of non-UK citizens in the UK by nationality group from 2000 to 2021, the longest period available. It gives an initial insight into the evolution of migration to the UK and especially offers intuitions of trends and fluctuations of EU and non-EU migrants to the UK through a series of external shocks such as rounds of EU expansions and more importantly, Brexit.





Notes: Population in thousands. EU14: includes fourteen founding and senior members of the EU, i.e., Austria, Belgium, Denmark, Finland, France, Germany, Greece, Republic of Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and Sweden. EU8: means eight Eastern European countries that joined the EU during the 2004 Enlargement, i.e., Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia. EU2: represents Bulgaria and Romania which joined the EU during the 2007 Enlargement. EU Other: involves Malta and Cyprus which joined the EU in 2004 as Mediterranean countries and Croatia which joined the EU in 2013. Non-EU: consists of all other regions other than the EU, including Asia, North America, etc. Sources: <u>ONS database</u> and <u>Annual Population Survey</u>. Data sources are cross verified by applying the Chi-Square test, which shows data quality for both sources are satisfying (p-value larger than 0.05 and low Chi-Square statistics).

Migration to the UK has been majorly encouraged by non-EU migrants in the past two decades with a steadily increasing trend. The population of non-EU citizens in the UK has increased by 86.3% from 2000 to 2021. EU migrants comprised of those from EU14, EU8, EU2, and other EU countries have also experienced a continuous rise from 2003 to 2017 but started to decrease since 2018 partially due to the lag effect of the Brexit decision made by the 2016 Referendum.

To be specific, the number of new migrants from EU14 countries to the UK remained stable from 2000 to 2010 and started to rise slightly since 2011. Migrants from EU8 countries increased significantly from the beginning of EU8 countries becoming EU members in 2004 and contributed the most to the augmentation of total EU migrants to the UK, which is echoed in several studies claiming that the 2004 EU enlargement is highly correlated with the substantial increase in EU migrants to the UK and Brexit debates on the migration policy and

far-right socioeconomic conservative opinions on migration are rooted in such correlation (Dennison and Geddes, 2018; Currie, 2016). Several other studies such as Ruhs & Vergas-Silva (2019) and Lomax et al. (2020) attribute the growing scale of EU migrants to the UK from 2004 to 2017 to the growing demand for job opportunities. According to Labour Force Survey data, the majority of both EU and non-EU migrants to the UK and Wales are labour migrants, which sheds light on this empirical study to focus more on migrants who seek jobs. In 2015 and 2016, the number of migrants from EU8 countries was almost equal to that of EU14 migrants, which seems to be abnormal given the fact that the population of the EU8 has been no more than 50% of that of the EU14 in the past two decades.

The Covid-19 pandemic originated in China also caused severe damage to the UK, causing 69,711 and 67,350 excess deaths in 2020 and 2021, respectively. However, as demonstrated in Figure 4.2, both EU and non-EU migration to the UK was not affected by the pandemic and followed trends in previous terms, which is consistent with findings from several studies which reveal that it is unlikely that people will make a future decision based on the current comparative severity of the pandemic in the move-in country since in most cases, they receive real-time Covid-19 data subject to daily volatility instead of long-term forecasts of volatility (Chakraborty & Maity, 2020). Nevertheless, the impacts of the pandemic on migration to the UK and Wales remain to be more thoroughly examined and will be discussed in the following sections.

4.1.2.3 Migration to Wales: Past and Present

According to data from ONS²⁶, historical trends of the population of EU and non-EU citizens in Wales show very similar patterns as in the UK. In 2021, there were 215,000 residents who were born outside the UK in Wales, 28.3% more than the figure in 2011. Regarding geographic features of migration to Wales, historical data shows that the main countries of birth are Poland, Germany, India, Ireland, the Philippines, South Africa, Romania, and the United States, and the main regions of origin are 8 accession countries that joined the EU in 2004, namely EU8 (35%), Asia and Oceania (28%), and EU14 (15%) since 2010. Particularly, the number of migrants who came from EU8 countries and lived in the UK has increased by 90% (highest among all regions of origin) from 2004 to 2020.

²⁶ <u>https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/internationalmigration</u>

Migrants from outside the UK to Wales are mainly young and employed. According to data from Labour Force Survey²⁷, about 50% of all migrants to Wales were in the range of 18-36 years old from 2015 to 2020 and 65% of them participated in full-time or part-time work in the Welsh labour force during this period. The top industries in which migrants in Wales join are manufacturing (26%), education (16%), tourism and hospitality (12%), and food and grocery (11%). Beckmann et al. (2009) notice a growing proportion of immigrants who work in the industry of higher education in Wales and demonstrate that a more diverse and inclusive environment and professional career services at Welsh universities have encouraged more international students and job seekers to work for universities. Evans et al. (2020) also find that the food and drink manufacturing industry has experienced rapid development since 2005 in Wales and has become one of the most popular employers among immigrants due to the expansion of major food and drink manufacturers such as Danone, Nestle, and Cadbury.





Source: Author's calculation based on ONS and Welsh Government data from 2000 to 2020. Notes: 1. Due to the availability of data, categorization of the EU group is not applicable, i.e., the employed population from EU14, EU8, EU2 and EU Other regions cannot be specified. 2. The estimated employment data in Wales is calculated as the equation: $E_{i,t} = P_{i,t}(1 - U_t)$, where $P_{i,t}$ represents the total working-age population of a certain nationality group *i* (here, EU or non-EU) at year *t* and U_t is the annual average unemployment rate of Wales at year *t*.

²⁷ The Labour Force Survey data requires permission.

https://www.ons.gov.uk/surveys/informationforhouseholdsandindividuals/householdandindividualsurveys/labourforcesurvey

To concentrate more on labour migration, Figure 4.3 demonstrates the author's estimation of the employed population in Wales from 2000 to 2020 based on the best of data availability. The employed population from the EU to Wales has increased in these two decades and only experiences two downturns in 2007 and 2016, the latter of which might also be induced by the 2016 Referendum. During this period, the non-EU employed population in Wales increased by 10.08% annually on average while the employed population originating from the EU increased by 15.45% annually on average and mainly contributed to the general trend. Starting from 2010, the number of EU-born employed population in Wales exceeded that of the non-EU employed population and became almost twice as many as the latter in 2016, which reveals the strong economic and social ties between Wales and the EU, especially regarding the issue of migration. We can also notice that the 2016 Referendum might have imposed negative impacts on EU migration decisions and resulted in a downturn of the number of EU labour migrants to Wales after 2016. However, the number of non-EU labour migrants to Wales started to decrease in 2015 but returned to increase since 2017 until 2020, showing that the 2016 Referendum seems to have had insignificant impacts on migration decisions for non-EU citizens who wished to stay in Wales. Due to data availability, time-series immigration data by specific nationality in Wales is unavailable but we assume the trend of dominant EU immigration in Wales should follow the trend in the UK based on strong socioeconomic ties between Wales and the EU.²⁸

To summarise, there are several main features of inward migration to Wales from outside the UK: (1) the number of EU migrants to Wales were close to that of non-EU migrants to Wales before 2010-2011 and started to grow rapidly since 2012, almost doubling the number of non-EU migrants during 2016-2017; (2) the majority of migrants to Wales have been working-age population and most of them are employed; (3) top 4 industries in which migrants in Wales join are manufacturing (26%), education (16%), tourism and hospitality (12%), and food and grocery (11%).

4.1.3 Hypotheses

It is estimated that migrants from both EU and non-EU countries to the UK will be negatively impacted by Brexit-restrictions on international migration, and numerous studies claim that EU migrants might suffer more from these restrictions than non-EU migrants due to additional requirements for applying for workers' visas imposed on EU citizens compared to the pre-

²⁸ Here is another reference to support the current trend of immigration patterns in Wales published by the Welsh Government, based on Census 2021 data: https://www.gov.wales/ethnic-group-national-identity-language-and-religion-wales-census-2021-html

Brexit era. However, due to regional and industrial heterogeneity existing in different regions of the UK, characteristics of pull factors that counteract discouraging effects of Brexit might result in highly different responses to Brexit for both EU and non-EU migrants. For instance, the construction industry in several local councils in England and Wales extremely relies on EU labour (Mohamed et al., 2017), which forms a strong pull factor that attracts EU migrants to these regions despite negative impacts of Brexit on migration. Meanwhile, the agglomeration theory implies that migrants tend to concentrate in industrial and economic centres of each region to reduce the transportation costs and maximise productivity. Thus, it is important to justify the regional heterogeneity in impacts of Brexit on migration to the UK across different UK regions. Additionally, migrants with various demographic backgrounds might lead to different proportions of labour with different ethnic origins and levels of skills across industries and regions.

As a result, this section focuses on impacts of Brexit on migration from outside the UK to Wales and especially highlight the regional, demographic, and industrial heterogeneity in such impacts and aims to examine potential mechanisms through which such impacts became reality. It is one major purpose of this thesis to measure different responses to Brexit among migrants with heterogeneous spatial, demographic, and industrial backgrounds. Meanwhile, it includes further discussions on future estimations of such impacts combined with two external shocks that might have long-lasting impacts on migration to Wales, i.e., the Covid-19 pandemic and the Ukrainian War. We finally arrive at the following further-developed hypotheses for this chapter:

- Brexit impacted patterns of migration to Wales and such impacts demonstrated regional, demographic, and industrial heterogeneity in Wales.
- (2) There are potential mechanisms through which Brexit imposed impacts on migration to Wales, such as trade and FDI that accelerated such impacts.
- (3) Patterns of migration to Wales will respond to potential long-term effects of Brexit, combined with impacts of the Covid-19 pandemic and the Ukrainian War.

4.2 Methodology

This empirical section contains two models to review the historical impacts of Brexit on migration to Wales and to forecast how migration to Wales will respond to Brexit, combined with influences of two major external shocks, namely the Covid-19 pandemic and the 2022 Russian Invasion of Ukraine. Given the availability of data, the empirical analysis is split into

two parts: review and forecast. Such design was considered because of two reasons. First, the majority of current quantitative studies measuring the impacts of Brexit have focused on how future international trade and UK economic growth will respond to Brexit (Booth et al., 2015; Aichele et al., 2015) while little attention has been paid on, which has a more direct mechanism, the impacts of Brexit on migration to the UK. A great number of empirical studies have clarified that migration is significantly correlated with local economic growth, trade, FDI, income, and other regional economic variables, which indicates that discussions on the impacts of Brexit on migration to Brexit since notable to review and examine how migration to Wales fluctuated due to Brexit since notable changes in migration patterns from the EU to the UK might have causal effects on bilateral trade and economic relations between the two regions.

Second, considering that a series of unexpected events might cause external and mixed effects on correlations between migration and Brexit, we include the latest data regarding two major events that could have influenced international migration since 2020, namely the Covid-19 pandemic and the 2022 Ukrainian War, to decompose such impacts and to re-estimate future trends of migration to Wales. More importantly, due to the features of data that includes both time-variant and invariant variables, other methodologies such as the random effects model and the spatial DSGE model might fail to illustrate the regression process of a combined set of variables based on the data availability regarding impacts of Brexit on migration to Wales. Although Section 3.4.3 reveals that the DSGE model can simulate impacts of policy shock such as Brexit on economic growth, reasons for not using the spatial DSGE model include: (1) the DSGE model has the presumption of rational expectation while the literature we reviewed have demonstrated the irrational factors in the process of Brexit, such as the anti-immigration ideology and isolationism-related economic policies that have inadequate data or empirical evidence; (2) the DSGE model is based on the foundation of solid micro-level data while our study does not have required volumes of individual or firm-level data especially in regions outside of Cardiff, which indicates that application of the DSGE model to our analysis might cause severe sampling bias.

In accordance with the data availability and hypotheses we have proposed, the FEVD-based gravity model and the NiGEM model are used to review impacts of Brexit on migration to Wales and to estimate such impacts in near future, respectively.

4.2.1 Gravity Model

The gravity model has been one of the most popular regional economic models for at least half a century and is also a commonly applied paradigm for research on spatial patterns of migration across regions. Stewart (1950) first developed the social physics school by inserting Newton's law of gravity into his studies on population movement between move-out and move-in regions. The gravity model of migration demonstrates the trend of both domestic and international migration which is influenced by the distance between the move-out and move-in regions and external push factors that encourage local residents to move out and pull factors that attract inward migrants. Even though the model has been redesigned into several extensions, it has the most commonly acknowledged and simplified form as follows:

$$M_{i,j} = G \frac{P_i^{\alpha} \times P_j^{\beta}}{D_{i,j}^{\gamma}}$$
(1)

where $M_{i,j}$ represents the number of migrants between areas *i* and *j* during a certain period; P_i and P_j refer to population scales of these two regions measured during the beginning of migration; $D_{i,j}$ refers to the distance between them. Finally, α , β , and γ are parameters and *G* denotes a constant measuring relative factor composition between these two regions. Usually, it is transformed into logarithmic form:

$$\ln M_{i,j} = \delta + \alpha \ln P_i + \beta \ln P_j - \gamma \ln D_{i,j} + \varepsilon_{ij}$$
(2)

where the error term ε_{ij} is introduced into the equation and δ replaces the constant of measurement *G*. Values of all parameters can vary greatly in size based on specific regional economic gaps between two regions. Stillwell et al. (2014) find that, with regard to internal migration, the estimated value of γ is between 1.5 and 1.6 in the setting of over 50 regions in the UK. Measuring these parameters in the context of international migration across regions might be more complicated due to mixed factors that could have impacts on trends of migration, such as gaps in regional economic growth, international trade, and exchange rate difference (ERD). Unexpected local or international events causing external impacts on migration, namely external shocks, might make such measurement more complex amid such an era of uncertainty.

As a component of spatial economic analysis, the influence of external shocks such as Brexit and the Covid-19 pandemic requires quantitative interpretation in the structure of the gravity model. Among hundreds of extended versions of the classical gravity model, Lowry (1966) revisited the push and pull theory and developed his version of the gravity model as follows:

$$M_{i,j} = k^{\theta_0} \frac{P_i^{\theta_1} P_j^{\theta_2}}{D_{i,j}^{\theta_3}} \cdot \prod_{s=1}^n \frac{X_{s,j}^{\alpha_s}}{X_{s,i}^{\beta_s}}$$
(3)

Take the logarithmic form:

$$\ln M_{i,j} = \theta_0 \ln k + \theta_1 \ln P_i + \theta_2 \ln P_j - \theta_3 \ln D_{i,j} + \sum_{s=1}^n (\ln X_{s,j}^{\alpha_s} - \ln X_{s,i}^{\beta_s}) + \varepsilon_{i,j}$$
(4)

where $X_{s,j}$ represents all exogenous variables that attract citizens from region *i* to *j*, namely pull factors, while $X_{s,i}$ denotes all exogenous variables that push citizens in the same direction, namely push factors. Theoretically, the number of migrants, $M_{i,j}$, is often positively correlated with population scales in the move-out region, P_i , while negatively correlated with the distance between these two regions, $D_{i,j}$. Push and pull factors include gaps in overall economic growths, quality of public services, and pollical stability between move-in and move-out regions with variables such as local GDP, unemployment rates, levels of education, income, infrastructure, political freedom, and coverage of social security.

4.2.2 Fixed-Effect Vector Decomposition (FEVD) Method

Correlations between endogenous variables (e.g., distance, differences in economic and political condition, etc.) and the actual migration decisions are significant to our study, while there are also multiple exogenous variables arising from unexpected events that could bring variations to such correlations. For example, after the outbreak of 2022 Russian Invasion of Ukraine, the number of migrants from both Russia and Ukraine to Wales might have increased rapidly. More relevantly, the additional restrictions on EU migration to the UK proposed by the Brexit agreement is more likely to impact EU migrants rather than non-EU migrants, although the EU region and UK are geographically much closer. The Ukrainian War, however, could make the estimation of migration from the EU to the UK more complicated due to highly potential waves of migrants from Eastern European countries due to the fear of the war. Such spatial interactions are included in both sections of review and forecast to measure the influence of external shocks in this study, namely Brexit, the pandemic, and the Ukraine War.

During the process of measuring all variables that could impact the correlation between Brexit and migration, the estimation of several time-invariant variables such as the distance between two regions and (in some cases especially for developed countries) population scales can benefit from the Fixed-Effects Vector Decomposition method. Plümper and Troeger (2007) have pointed out that the classical fixed-effect model might include significant bias of timeinvariant variables and final estimations of these variables can have much distortion. FEVD can be a very powerful estimator in some specific settings, and it controls estimation bias for variables that have extremely little within variance without causing more regression errors to other variables. In this study, the population size of Wales and some developed countries, GDP per capita, and distances between Wales and move-out countries can be considered as "stable variables" that can be measured with the FEVD method.

More importantly, independent variables with different levels of within variance might have variant impacts on migration decisions. It is highly possible that variables with little within variance will lead to lag effects on migration patterns, making little difference in trends of migration. For example, India has been a migrant exporter to the UK, which is consistent with a theoretical finding that the direction of migration is likely to be from regions with lower GDP per capita to regions with higher GDP per capita. On the contrary, variables with large within variance are likely to have greater impacts on the migration decision, namely Brexit, or free movement rights across regions in this study.

4.2.3 Empirical Model

Empirically, we developed a further extended version of the FEVD-based gravity model which can be demonstrated by Equation (5) as follows:

$$M_{i,j,t} = \beta_0 + \beta_1 P_{i,t-1} + \beta_2 P_{j,t-1} + \beta_3 D_{i,j} + \beta_4 U_{i,t-1} + \beta_5 U_{j,t-1} + \beta_6 G_{i,t-1} + \beta_7 G_{j,t-1} + \beta_8 E U_{i,t-1} + \beta_9 E R_{i,j,t-1} + \beta_{10} C_{i,j,t-1} + \varepsilon_{i,j,t-1}$$
(5)

where $M_{i,j,t}$ is the logarithm of the number of migrants from country *i* to *j* (Wales) at time *t*; $P_{i,t-1}$ and $P_{j,t-1}$ denote the logarithm of lag population scales of the move-out country and Wales at time t - 1; $D_{i,j}$ is the distance; $U_{i,t-1}$ and $U_{j,t-1}$ represent the logarithms of unemployment rates in the move-out country and Wales at time t - 1; $G_{i,t-1}$ and $G_{j,t-1}$ are logarithms of GDP per capita in both regions at time t - 1; $ER_{i,j,t-1}$ means the logarithm of the exchange rate of the currency of the move-out country with the British pound (GBP). Among all control variables, the aggregate GDP controls for macroeconomic growth in both regions and can be considered as a proxy for income levels. Reduction in GDP in move-out regions is believed to have significant positive impacts on migration as a push factor. An increase in GDP in the destination is likely to pull migrants since it is highly correlated with more job opportunities. The exchange rate controls for variations in financial markets in both regions. Region and year fixed effects are included in all regressions.

More importantly, $EU_{i,t-1}$ represents the independent variable that decides whether migrants in country *i* have the right of free movement to the UK at time t - 1, and takes the value of 1 if this country has free movement rights to the UK and takes the value of 0 if it not, which presents the indicator of Brexit. $C_{i,j,t-1}$ denotes the Covid-19 parameter which measures the relative severity of the Covid-19 pandemic in the move-out country compared to Wales. It is calculated by the following equation:

$$C_{i,j,t-1} = \frac{NC_{i,t-1}}{NC_{j,t-1}}$$
(6)

where $NC_{i,t-1}$ and $NC_{j,t-1}$ denote the number of monthly new Covid-19 cases in both regions at time t - 1 from January 2020 to January 2022. Several studies use the dummy variable to measure the relative conditions of the pandemic across regions and set the value to be 1 from 2020 to 2021 and 0 after 2022 (Takenaka et al., 2020; Khanna, 2020). To the best of our knowledge, such an approach has two drawbacks. First, it is still debatable whether all countries have entered the post-pandemic era with significantly few cases. Second, due to the data availability, it will cause statistical bias in these empirical studies on impacts of the pandemic on migration since little data after 2022 matching the hypothesis of post-pandemic condition with the Covid-19 dummy equalling to 0 can be obtained, which indicates that this dummy variable needs to be decomposed.

Thus, we developed the calculation method above and included the logarithmic form of the pandemic variable based on two reasons. First, the number of monthly new Covid-19 cases is the most direct and feasible data to measure the condition of the Covid-19 pandemic in different countries. Some other measurements such as Covid-19 death cases remain controversial due to the ambiguous definition. Second, according to WHO data, almost all countries in the world had Covid-19 cases and updated daily new cases in due course since 2020, which meets data requirements of the model.

To further examine how employed migration belonging to different categories (see Table 3.1) in Wales responded to Brexit, the regression is repeated three times (except for the initial regression using the data of total migrants to Wales) to measure the same mechanism for EU employed migrants who earn no less than £30,000 and less than £30,000, and non-EU

employed migrants who earn no less than £30,000 in Wales. Impacts of Brexit on labour migration to Wales can be more clearly demonstrated by adopting this method and will arouse concerns over subnational-level responses to labour migration policies against Brexit in the UK, which, to the best of author's knowledge, has not been covered by any current literature.

4.2.4 NiGEM Model

The National Institute Global Econometric Model (NiGEM) has been a leading global and regional macroeconomic model which consists of thousands of variables, agents, and many specific versions to fit different regions. It has been widely used by economists and policymakers to conduct economic forecasting and stress testing. Since it was developed in 1987, the NiGEM has been applied to numerous empirical studies on spatial economic analysis, including topics regarding impacts of Brexit in the UK. Ebell & Warren (2016) use NiGEM to forecast how the UK economy will respond to Brexit in the long run and focus on reductions in trade between the UK and EU, in FDI, and in UK's net fiscal contribution to the EU. They conclude that various reductions in UK GDP will emerge in different scenarios by 2030. Baker et al. (2016) estimated the short-term economic impact of Brexit on the UK economy and showed that the UK GDP would experience around a 2.5% of decrease 2 years after the decision of Brexit would be made. Another study forecasts that in 2030 UK GDP per capita will be around 3% lower than the scenario of Brexit not happening if the UK signs an FTA with the EU, 1.9% lower if the UK remains close relations with the EU and stays in the EU customs union, and 3.7% lower if the UK totally adopts WTO frames on trade with the EU (Hantzsche, et al., 2019).

Relevant studies on future impacts of Brexit on the UK economy might encounter an important issue of policy uncertainty, especially regarding negotiations of the EU-UK bilateral economic relationship. Debates on designs of the customs zone in Northern Ireland and the trade status between this region and the EU have continued even after UK prime minister Rishi Sunak made an initial agreement with the President of the European Commission von der Leyen (The Conversation, 2023). Such uncertainty might cause remarkable estimation bias in these studies and if it is not considered in empirical models, the negative impacts of Brexit on trade between the UK and EU are likely to be underestimated. On the contrary, restrictions on migration to the UK have been notified at the beginning of Brexit negotiations and have been decided in the final Brexit agreement, providing fewer risks of estimation bias from the perspective of policies.

To forecast future migration to Wales, we apply the Welsh version of NiGEM developed by NIESR and Cardiff University, which includes unique features and agents in the Welsh economy. As stated in previous sections, this study will not follow the scenario of measuring impacts of Brexit on the economy directly but adopt the scenario of measuring such impacts on migration to Wales given that the covariance between these two scenarios might cause bias on spatial economic analysis of Brexit. This model consists of basic variables of economic agents as listed in Hantzsche et al. (2018) and detailed explanations of these variables are included in their paper.

Regarding model specification, the original NiGEM includes around 6,000 variables and over 10,000 model equations to provide essential data of all relevant independent variables for estimation of specific projects or events' economic impacts. The Welsh-version NiGEM also includes around 4,000 variables and over 7,000 equations given that the Welsh economy is considered an open economy. Key agents in the Welsh-version NiGEM settings are households, firms, governments, and monetary authorities, including agents of the Welsh economy, namely households, firms in Wales, the Welsh government, and the UK monetary authority due to Wales being a part of UK. Major variables in each agent are: 1) consumption, labour supply, income, and investment for households; 2) capital, labour demand, energy demand, and investment for firms; 3) taxation, public expenditure, and debt for governments; 4) interest rates and exchange rates for monetary authorities. Figure 4.4 shows the framework of NiGEM variables and equations specification, which are the foundation of the Welsh-based NiGEM model utilised in our analysis.


Figure 4.4 Framework of the NiGEM model specification

Source: The NiGEM model manual, National Institute of Economic and Social Research.

The benchmark empirical model to forecast is the same as the extended version FEVD gravity model demonstrated in Equation (5) except for one additional dummy variable which equals to 1 if the move-out country belongs to EU8 or EU2, closet to Ukraine, or the move-out country shares its borders with Ukraine and equals to 0 if it is not in the designated category above. The gravity model claims that the distance has been one of the most important factors that influence the migration decision. It is more likely that citizens living in countries contiguous to Ukraine tend to migrate for the reason of security than those living far away from Ukraine. Numerous papers and reports published in 2022 and 2023 expected that the Russian Invasion of Ukraine could last for months, even years, which makes it valuable to be considered in the model. In the forecast settings, the variable of Covid-19 relative coefficient measured by Equation (6) will be removed since according to WHO data, Covid-19 new cases in almost all countries have been declining to an extremely low level since the beginning of 2023, and multiple countries including the US and UK have announced that the pandemic is over, which implies that the impacts of the Covid-19 pandemic on migration can be negligible. The extended model is inserted in the Welsh-version NiGEM to perform the forecast of future migration trends to Wales.

4.3 Data and Variables4.3.1 Data Description

Spatial economic analysis on migration usually requires two dimensions of data, namely the temporal and spatial dimensions. Panel datasets allow the combination of these two dimensions and can give unbiased regression results and account for individual heterogeneity compared to time-series data. Regarding migration analysis, both spatial gaps and time-series variation are critical to identifying main factors that impact migration decisions.

This empirical study mainly uses open-source databases, and the major sources of data are Office of National Statistics (ONS) and the Welsh Government. ONS gives the data of the population of Wales, the unemployment rate in Wales, and GDP per capita of Wales from 2000 to 2022. Welsh Government and the Labour Force Survey (LFS) database²⁹ provide data of three categories of labour migrants in Wales from 2000 to 2022. The data of Covid-19 new cases from January 2020 to January 2022 comes from WHO collections of Covid-19 database. The World Bank database provides the data of exchange rates between the UK and move-out countries from 2000 to 2022. In total, data of migrants from 156 countries to Wales is utilized in this study, and 62% of them come from non-EU countries and 38% of them come from EU countries. Datasets used in two sections, namely review and forecast, are the same. In summary, there are 3,432 samples that include the migration and economic data from 156 countries in 22 years. Data sources include ONS and LFS data with ONS providing a big picture of immigration status and LFS providing individual-level data of immigration, employment (industry), and demographic information, thus it is believed that the data has good quality. It is indeed with limitations due to data availability in Wales, but the author has made all efforts to eliminate potential bias.

The Labour Force Survey (LFS) data primarily represent the total immigrant population stock, not just recently arrived immigrants. It captures the employment, demographic, and socioeconomic characteristics of individuals in private households, including both long-term residents and recent arrivals who are part of the labour force or economically inactive.

Brexit has important and dynamic impacts on the decision to immigrate or remain, which is why the LFS data was used. It provides time-series individual-level data of immigration status. The empirical analysis in Chapter 4 uses the variable of country of birth to identify whether each sample individual was an immigrant in that year. This can demonstrate time-series changes to the number of total immigrants in Wales in every year. I believe such changes can

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 $[\]label{eq:https://www.ons.gov.uk/file?uri=/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/methodologies/labourforcesurveyuserguidance/volume1backgroundandmethodology2024.pdf$

also reveal everyone's decision to move to or leave Wales in the sample period. It is also important to note that the dependent variable is the number of immigrants from each move-out country to Wales in each year based on annual LFS data, which reveals the real (and changing) immigration condition in Wales during the sample period (2000-2022).

The LFS primarily collects data on individuals participating in economic activities, so it emphasizes migrant workers, defined as: individuals born in another country or region who are currently employed or seeking employment in the host country. According to existing studies, it is believed that the majority of inward immigrants in the UK and Wales are migrant workers, and LFS is the only individual-level data source for micro-analysis on impacts of Brexit on inward immigration. Thus, analysing dynamics of migrant workers in Wales before and after Brexit could shed light on such impacts and encourage future analysis. LFS data provides dynamics of the number of immigrants from all sample countries of birth to Wales during the sample period, and the data shows the value of the number of immigrants from each sample country of birth to Wales each year with the information of annual income and industries. The information of when each sample migrant worker arrived in Wales is not available in LFS database, and it is irrelevant to the research question.

LFS data derived for empirical analysis of this chapter includes the information of migrant workers from 156 countries, and the number of them from each country of origin ranges from dozens to thousands, showing various patterns of immigration from different countries of origin.

4.3.2 Variables

As mentioned previously, our analysis aims to examine impacts of Brexit on migration to Wales, thus the independent variable is the Brexit-related dummy variable, i.e., the variable of EU free movement right which was abolished after Brexit, and the dependent variable is the number of international migrants from outside the UK to Wales. The suspension of EU free movement rights from the EU region to the UK is considered as the most significant and direct impact of Brexit on migration to the UK (Parker, 2017). Before Brexit, EU citizens were not required to apply for workers' visas if they would like to migrate to the UK. After Brexit, EU citizens have been required to apply for visas of migration, which is a critical turning point that might have impacts on both EU and non-EU citizens and provides the feasibility of choosing this variable as the independent variable for our study. In addition, we include several control variables to

eliminate internal heterogeneity and its impact on correlations between Brexit and migration to Wales.

4.3.2.1 Migration to Wales

As the dependent variable, the number of international migrants from outside the UK to Wales explicitly demonstrates the historical changes in the trend of migration to Wales. Data of migrants to Wales is divided into several groups: (1) based on countries of birth of migrants to Wales, migrants to Wales are categorised into two groups, i.e., those from EU and non-EU countries; (2) based on income levels of migrants to Wales, they can be divided into two groups, i.e., those earning no less and less than £30,000 per annum. Thus, the categories of migrants to Wales are allocated to into 3 groups: EU migrants earning less and no less than £30,000 per annum and non-EU migrants earning no less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants earning less than £30,000 per annum since non-EU migrants to Wales.

4.3.2.2 EU Free Movement

Restrictions on international migration to the UK have been largely impacted by Brexit-related immigration policies that further impose extra requirements for EU citizens who would like to migrate to the UK. More specifically, after Brexit, all EU migrants to the UK have been asked to apply for regular workers' visas to obtain the right to work and live in the UK, which used to be only imposed on non-EU migrants. Thus, the most important measurement of changes in the UK immigration policy due to Brexit is the existence of EU free movement which was prohibited by the current policy. For non-EU migrants, the fact that the free movement right for EU migrants does not exist anymore due to Brexit might not have imposed direct impacts on their migration decisions, but still could trigger influences in two aspects. First, it might encourage them to accelerate their migration decisions since the competition of applying for workers' visas might be fiercer after Brexit due to EU migrants being moved into the pool of applicants who seek for living in the UK. It is also important to note that EU migrants usually have better performance in the English language and share similar cultural backgrounds with UK citizens than non-EU migrants, which might impose more pressure on non-EU migrants and lead to a speedier decision of migration to the UK before Brexit became reality. Considering recent geopolitical events, we also assume that such acceleration of decisionmaking process is consistent with urgent demands for migration to the UK especially for those in Hong Kong and Ukraine who suffered from political persecution and conflicts. Second, the

unexpected result of the 2016 Referendum might have given non-EU migrants a perception that the UK immigration policy could be unstable, and it might be a better option to consider other destinations for migration, such as Canada and Australia, which is further illustrated by Lo et al. (2019) who find that migrants from China and India to Canada and the US increased rapidly in 2014-2018 partially due to concerns over the stability of immigration policies in several countries including the UK.

Thus, we introduce the EU free movement dummy variable as one of the core independent variables that can examine impacts of Brexit-related immigration restrictions on international migration for this study, and it equals to 1 if the specific country i has the agreement of free movement rights with the UK and equals to 0 otherwise.

In terms of the issue of "stepped" immigration, since the dependent variable of the constructed gravity model is the number of immigrants from their countries of birth to Wales, according to LFS data, it might be safe to justify the gravity model can measure dynamics of immigration patterns of different groups of immigrants to Wales, regardless of various types of immigration. It is also very true that, according to existing literature, "stepped" immigration accounts for an extremely small proportion of the total immigration to the UK, and the majority of immigrants to the UK adopted direct routes of immigration instead of the "stepped" way (Begum et al., 2019; King, 2021). The small amount of "stepped" migrants to the UK could result from the similarity of economic growth in the UK, France, Germany, and other major European move-in destination countries, and the complexity of "stepped" immigration. Such patterns should be applied to the case of Wales as well. Thus, it is not problematic to use the gravity model to analyse how Brexit impacted immigration to Wales.

4.3.2.3 Control Variables

Several major control variables have been included to reflect the relative economic growth and demographic patterns in both move-in and move-out regions and might have impacts on migration to Wales. These variables are:

(1) The population density in both regions. Numerous studies have revealed a significantly positive correlations between the out-migration motivation and the population density in the move-out regions (Rees et al., 2017; Sato, 2007). Normally, migration happens from a higher-population density region to a relatively lower-population-density region

in order to seek for more endowments per capita. Census 2021 data provided by ONS³⁰ show that India and China are two of the most important countries of birth among all migrants to the UK while both countries own extremely high population densities.

- (2) Distance. Considering the costs of international migration, we assume that a shorter distance between the move-in and move-out regions might result in a more significant motivation for migration. Schwartz (1973) further claims that the distance between two regions might also be correlated with the socioeconomic and cultural closeness that have impacts on migration decisions. However, some recent studies also use the case of migrants from China to the US to claim that the distance might not have significant impacts on the number of migrants from certain regions to the destination country as long as the pull factor is strong enough to attract migrants (Liang & Chunyu, 2013). Thus, whether the distance between move-out countries and Wales remains to be analysed. The FEVD method is applied to controlling for the distance variable due to its time-invariant feature.
- (3) *GDP per capita*. Regions with higher GDP per capita usually provide higher-level public services and more career opportunities than regions with lower GDP per capita, which becomes another significant indicator to attract migration (Matsui & Raymer, 2020). The GDP per capita in Wales in 2022 was estimated to be £27,435 according to the author's calculation based on ONS data³¹, which ranked the top 20% among all countries in the world. Thus, we consider GDP per capita as a control variable and also examine the impacts of gaps in GDP per capita between move-out regions and Wales on migration to Wales.
- (4) Unemployment rate. Considering that one of major purposes of migration is to seek for job opportunities with higher income, we include the control variable of unemployment rates in both move-out countries and Wales and also aim to examine how gaps in the unemployment rates between move-out and move-in regions contribute to changes in the number of migrants to Wales. It is also important to note that the unemployment rates in Wales remained stable and did not experience significant fluctuations in the sample period of our study (2000-2022) except the period of 2007-2010 when the global financial crisis hit almost all regions in the world including Wales. By controlling this
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https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/internationalmigration/articles/thechanging pictureoflongterminternationalmigrationenglandandwales/census2021

³¹ <u>https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/quarterlycountryandregionalgdp</u>

variable, we also notice that external shocks such as the 2008 Financial Crisis presented systematic shocks that influenced the unemployment rates in almost all economies.

4.3.2.4 The Covid-19 Indicator

The calculation method to measure the severity of Covid-19 pandemic is developed, shown in Equation (6) and included the logarithmic form of the pandemic variable based on two reasons. First, the most immediate and practical indicator for assessing the state of the Covid-19 pandemic in various countries is the monthly influx of new Covid-19 cases. Other metrics like Covid-19-related deaths can be contentious due to their uncertain definitions. Second, as per data from the World Health Organization (WHO), nearly all countries across the globe have reported Covid-19 cases and continually provide updates on their daily case counts since 2020, aligning with the data criteria of the model.

It is also important to focus on potential temporary shocks in international migration due to the Covid-19 pandemic which extremely prevented flows of migration across the world. This pandemic, originated from China, has spread around the world and the UK also suffered from high casualties in 2020 and 2021 due to different variants, inefficient public policies, and the overwhelmed NHS system (Couper et al., 2022). In 2020 and 2021, the UK government proposed rounds of pandemic-control restrictions such as the lock-down policy and the legal requirement of wearing masks. Among all of these restrictions, the lock-down policy might have imposed negative impacts on international migration to the UK, while during the same period numerous countries applied the same policy to control the pandemic, which leads to difficulties of migration and the deferral of migration decision. Since 2022, the pandemic in the UK was gradually under control with the declining fatality rate of new variants and the increasing coverage of vaccines, and the UK finally entered the post-pandemic period in 2023 when almost all pandemic-related restrictions were abolished.

4.3.2.5 The Ukrainian War Dummy

The outbreak of the Ukrainian War is considered to be a result of the current geopolitical and ideological dispute between Russia and the NATO group influenced by the US while such dispute in a wider background, i.e., between the East and the West, has demonstrated itself in many other ways such as the de-coupling campaign between the US and China (Mearsheimer, 2022). The current and potential geopolitical conflicts in such an era of uncertainty cannot be ignored since these conflicts might have significant impacts on international migration.

As is mentioned in previous sections, multiple studies notice that migrants from Ukraine and other Eastern European countries to other regions, especially the US and the UK, increased rapidly after the outbreak of Russian Invasion in 2022. Although migrants from Ukraine to the UK are considered as refugees, there are still a large proportion of Ukrainian refugees who seek for permanent status and job opportunities in the UK, making them qualified to be migrants to the UK (Kulu et al., 2023). In addition, there could be the spillover effect brought by the Ukrainian War which leads to considerably increasing migrants from Eastern European countries sharing borders with Ukraine, such as Poland and Romania (Konstantinov et al., 2023). It is important to note that, as is mentioned previously, migrants from Romania are one of the largest migrant groups in the UK, which makes it essential to measure the spillover effect of the war and forecast impacts of this war on migration to Wales.

4.4 Main Results

4.4.1 Review: Overall Impacts of Brexit on Migration to Wales

Table 4.1 shows descriptive statistics of all variables based on the FEVD gravity model for review. The population density of the move-out country varies significantly and the distance between the UK and the move-out country also shows great variation given the remarkable gap in the distance from the closest Ireland (around 200 kilometres to Wales) to the farthest New Zealand (around 18,000 kilometres to Wales). On the contrary, all Wales-related variables such as the population, unemployment rate, and GDP per capita in Wales are relatively stable during 2000-2022. It might be the result of Wales being a developed economy so that a gentle increase in population and GDP per capita has been witnessed. We also calculated the logarithmic values of these time-invariant variables in the UK and found that Wales has shared very similar trends with the UK.

More specifically, the unemployment rates in the move-out countries also have significant standard deviations compared to the unemployment rate in Wales during the sample period, showing that the conditions of job markets in move-out countries were apparently heterogeneous and not all migrants to Wales have come from regions with high unemployment rates. As such, we assume that seeking for job opportunities is one purpose to migrate but does not represent all motivations of migration. Following the features of unemployment rates in move-out regions, GDP per capita also demonstrates significant regional heterogeneity among all move-out countries, while Wales did not witness significant fluctuations in GDP per capita during the sample period. We believe relatively large standard deviations of unemployment

rates and GDP per capita in move-out countries can be attributed to the wide range of countries of birth where migrants to Wales used to live before their migration. The mean value of the EU dummy is 0.188, showing the majority of migrants to Wales came from non-EU countries during the sample period or EU countries after Brexit which suspended the EU free movement right. The Covid-19 pandemic variable also shows high a standard deviation, indicating that the severity of the pandemic significantly varied in different countries.

Variables	Mean	S.D.	Min	Max	Operationalization
P_i	3.998	1.779	2.305	6.147	Population density of the move-
					out country in thousands, logged
P_{j}	3.478	0.233	3.462	3.491	Population density of Wales in
					thousands, logged
$D_{i,j}$	3.667	1.981	2.301	4.982	Distance in kilometres, logged ¹
U_i	0.993	0.777	0.554	1.375	Unemployment rate of the move-
					out country in percentage, logged ²
U_i	0.867	0.076	0.778	1.041	Unemployment rate of Wales in
,					percentage, logged
G_i	3.902	3.763	2.789	5.146	GDP per capita of the move-out
					country in USD, logged ³
G_i	4.301	0.112	4.204	4.378	GDP per capita of Wales in USD,
,					logged
EU_i	0.188	0.467	0	1	Dummy variable
$C_{i,i}$	5.023	6.665	2.274	8.921	Covid-19 severity measurement
.,,					based on Equation (6), logged

Table 4.1 Summary statistics and operationalizations

Notes: 1: The data of distances between Wales and selected countries is retrieved from the world distance calculator based on the direct flight distance between two countries, namely between the UK and the move-out country in this study. The calculator is provided by https://distancecalculator.globefeed.com/World_Distance_Calculator.asp. 2 and 3: Multiple sources of unemployment and GDP per capita data are available in several countries, and especially in China, data reliability remains to be examined. We use the data of these variables from the World Bank database and official statements issued by governments or economic departments.

Table 4.2 demonstrates empirical results of impacts of Brexit on total migration to Wales from 2000 to 2022 based on FEVD gravity model estimates in three scenarios. The first scenario measures coefficients without considering the EU free movement and the Covid-19 pandemic, while the second scenario adds the EU free movement to the scheme and the third scenario includes both the EU free movement and the pandemic. It first shows that several variables did not impose much influence on the total migration to Wales in all scenarios. Given that the annual population growth rate of Wales has been smaller than 0.5% and the unemployment rate in Wales has quite small standard deviations during this period, both of the population and unemployment rate in Wales are not significant determinants in this model. The GDP per capita in Wales has also not changed too dramatically, which makes it another insignificant determinant.

Relatively, the population of the move-out country has a significant impact on migration to Wales, possibly due to the rapidly increasing figure of migrants from China and India, two most populous countries in the world. The coefficients of distance show a much stronger impact that the closer the move-out country is to Wales, the more its migrants will come, which is consistent with that the majority of migrants to Wales came from the EU since 2010. A higher level of unemployment rate and a lower level of GDP per capita in the move-out country are likely to bring more migrants to Wales. It echoes De Haas et al. (2019) who measure determinants of international migration and claim that relatively lower levels of employment prospects and output are major determinants that push migrants to other countries. The growth in GDP per capita of Wales (from £10,793 in 2000 to an estimated £24,782 in 2022, Welsh Government) also makes it a significant determinant that encourages more migrants.

Variable	e Number of international migrants to Wales				
	Ι	II	III		
Population (Move-out)	0.092**	0.088**	0.081**		
	(0.009)	(0.008)	(0.007)		
Population (Wales)	0.059	0.043	0.053		
	(0.249)	(0.139)	(0.247)		
Distance	-0.728**	-0.560**	-0.675 **		
	(0.006)	(0.006)	(0.005)		
Unemployment rate (Wales)	-0.012	-0.016	-0.014		
	(0.732)	(0.824)	(0.728)		
Unemployment rate (Move-out)	0.445***	0.456***	0.442***		
	(0.000)	(0.000)	(0.000)		
GDP per capita (Wales)	0.057	0.054	0.057		
	(0.073)	(0.094)	(0.099)		
GDP per capita (Move-out)	-0.208***	-0.162***	-0.155***		
	(0.000)	(0.000)	(0.000)		
EU free movement	-	0.831***	0.414***		
	-	(0.000)	(0.000)		
Covid-19	-	-	0.006*		
	-	-	(0.032)		
Region FE	Yes	Yes	Yes		
Year FE	Yes	Yes	Yes		
Constant	0.516***	0.475***	0.445***		
	(0.000)	(0.000)	(0.000)		
Observations	3432	3432	3432		
Within R ²	0.178	0.182	0.177		
I-P-Shin test W[t-bar]	-2.56	-3.11	-6.19		

Table	4.2 Impacts of	Brexit on	migration to	Wales	(FEVD-ba	ased gravit	y mode	l estimates)
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Note: Consistent with the requirements of the FEVD method, the covariates of population (move-out and Wales) and distance is treated as stable variables and their standard errors are robust to heteroskedasticity. The I-P-Shin statistics reject the null hypothesis of nonstationarity. ***P < 0.001, ** P < 0.01, * P < 0.05.

More importantly, the 2nd and 3rd scenarios introduce main independent variables. The 2nd scenario controls for all other variables and includes the EU free movement dummy variable which measures impacts of Brexit on the total migration to Wales historically. The EU-free-movement coefficient is relatively large (0.831) with p<0.01, showing that having the right of free movement to the UK under the framework of the UK-EU migration policy will significantly encourage migration to Wales. This result is highly consistent with the current literature but indicates that, based on the large coefficient, impacts of losing the right of free movement on migration decisions due to Brexit might be even more striking than previous estimations (Portes, 2022). Such empirical gaps could be attributable to several reasons. First, most of the current literature has not included latest data especially after the outbreak of the pandemic while the external shock of the pandemic might have been imposed on migration. Second, few relevant studies on impacts of Brexit on migration to the UK applied the FEVD method to analysing variables with extremely small variances, which might cause bias of heteroskedasticity.

The 3rd scenario examines whether the Covid-19 pandemic has had impacts on migration to Wales. Even though the p-value is smaller than 0.05 showing the relative significance in the mechanism of influencing migration, the coefficient is too small to be considered as a significant determinant that encourages migration. Several studies such as McAuliffe et al. (2022) and Kaur et al. (2023) claim that there is a lag effect of pandemic-driven international migration since the spread of Covid-19 virus and changes in severity of the pandemic in different countries are usually a time-costing process. By the end of 2020, almost all countries in the world reported Covid-19 cases, making it more likely that the migration decision is not disrupted by the pandemic. WHO data also shows that daily new cases of Covid-19 in the UK ranked the most in the world for more than 50 days in 2020 and 2021, making it one of the most seriously affected areas of the pandemic. It might be safe to assume that, at least until now, the decision of migration to the UK is unlikely to be affected by the severity of the pandemic based on the lag effect and the extremely small coefficient of Covid-19 variable in the model.

In terms of R-square values in Table 4.2, existing studies such as Ozili (2023) and Morck et al. (2013) have revealed that feasibility of regression analysis depends on different values of R-square for different social science analysis, and results of analysing overall impacts of complicated policy shocks, such as Brexit, could possibly include relatively low values of R-square, which highlights the significance of decomposing such impacts by categorising

"victims" of such policy shocks and focusing on between-group heterogeneity. In addition, as is stated in Sections 4.4.1 and 4.4.2, Brexit is expected to have very diverse impacts on different groups of inward immigrants in Wales, based on their countries of birth (EU or non-EU) and income levels (over or below the post-Brexit immigration income requirements). Thus, when mixing these impacts into the general regression analysis as shown in Section 4.4.1, bias is expected to exist, which is confirmed by relatively low values of R-square and further emphasises necessity of heterogeneity analysis.

4.4.2 Review: Demographic and Industrial Heterogeneity

The same regression process shown above is repeated three times to measure the demographic heterogeneity based on the same mechanism with three dependent variables, namely EU migrants earning no less and less than £30,000 per annum and non-EU migrants earning no less than the same figure in Wales (See Tables 4.3, 4.4, and 4.5). The setting of 3 scenarios is to examine impacts of Brexit on EU/non-EU inward migration to Wales during the sample period 2000-2022 by dividing this period into 3 stages i.e., before the 2016 Referendum, after the 2016 Referendum and before 2021 effectiveness of Brexit agreements, and after 2021 effectiveness of Brexit agreements. Thus, before the actual effectiveness of Brexit, the £30k regulation was not a law and EU migrants with annual income lower than £30k still had access to free movement rights to migrate to the UK, including Wales. However, as is discussed in Section 4.1, Brexit-related uncertainty started from the referendum and is also important for analysing how Brexit impacted inward migration to Wales in past decades. For the 2nd scenario, the dummy variable of EU-UK free movement rights is used to measure impacts of Brexitrelated uncertainty on inward migration, especially from the EU after the referendum since the Brexit decision means UK-EU free movement rights would be stopped. For the 3rd scenario, with free movement rights abolished, the Covid-19 variable is introduced in the model to measure whether the pandemic has caused external impacts on correlations between Brexit and inward migration to Wales.

Coefficients of stable variables in three regressions show the same insignificant feature as the original regression shown in Table 4.3. However, in the regression with the dependent variable of EU migrants earning less than £30,000 per annum, the coefficients of EU free movement dummy variable are even larger in the 2nd and 3rd scenarios compared with the original one, showing that low-income EU migrants will be the most significantly impacted group among all categories of migrants to Wales. In the regression with the dependent variable of non-EU

migrants earning no less than £30,000 per annum, the EU free movement dummy variable becomes an insignificant determinant, while the variable of the population in the move-out country shows coefficients of 0.236 and 0.278 with p values smaller than 0.001 in the 2nd and 3rd scenarios, respectively. It might be attributed to migrants from India and China becoming the two largest sources of migrants among all non-EU countries according to ONS data of migration. Finally, with regard to the industrial heterogeneity, we performed the same regression for major industries in Wales and find that EU migrants in the construction and manufacturing industries received the most significant impacts from Brexit-related restrictions on migration to the UK while non-EU migrants did not receive significantly negative impacts of such restrictions in all major industries and demonstrate significantly positive impacts of Brexit in industries of financial services and education. This finding is critical since it reveals that Brexit might have significantly discouraged EU migrants in the secondary industry but encouraged non-EU migrants in the tertiary sector. It might also be related to heterogeneous levels of skillsets owned by EU and non-EU migrants, which requires further analysis in the future given the data availability of the number of labour migrants with specific levels of skillsets in Wales.

In conclusion, Table 4.3 reveals results of impacts of Brexit on EU immigration to Wales for those who annually earned less than £30k and still had free movement rights during the majority of sample period, i.e., 2000-2021. Meanwhile, as is discussed by numerous studies such as Bogacki et al. (2024), a small amount of EU immigrants still have had access to live in the UK through several immigration routes, including the "trading points" system for jobs in a shortage occupation or with a PhD degree, and low-income schemes of family visa . Thus, it is still meaningful to analyse impacts of Brexit on low-income EU migrants to Wales even after 2021 since there are still possible ways for them to migrant to Wales.

Variable	Ι	II	III
Population (Move-out)	0.082**	0.085**	0.089**
	(0.008)	(0.007)	(0.008)
Population (Wales)	0.034	0.046	0.043
	(0.145)	(0.121)	(0.243)
Distance	-0.089	-0.070	-0.078
	(0.195)	(0.216)	(0.175)
Unemployment rate (Wales)	-0.013	-0.009	-0.012
	(0.699)	(0.731)	(0.529)
Unemployment rate (Move-out)	0.425***	0.458***	0.428***
	(0.000)	(0.000)	(0.000)

Table 4.3 Impacts of Brexit on EU migrants earning less than £30,000 per annum to Wales

GDP per capita (Wales)	0.132	0.133	0.152
	(0.178)	(0.184)	(0.192)
GDP per capita (Move-out)	-0.121***	-0.135***	-0.129***
	(0.000)	(0.000)	(0.000)
EU free movement	-	0.939***	0.824***
	-	(0.000)	(0.000)
Covid-19	-	-	0.003*
	-	_	(0.041)
Region FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Constant	0.471***	0.472***	0.457***
	(0.000)	(0.000)	(0.000)
Observations	689	689	689
\mathbb{R}^2	0.875	0.752	0.771
I-P-Shin test W[t-bar]	-2.88	-3.36	-2.22

Note: Consistent with the requirements of the FEVD method, the covariates of population (move-out and Wales) and distance is treated as stable variables and their standard errors are robust to heteroskedasticity. The I-P-Shin statistics reject the null hypothesis of nonstationarity. ***P < 0.001, ** P < 0.01, * P < 0.05.

Variable	Ι	II	III
Population (Move-out)	0.004	0.006	0.005
	(0.724)	(0.887)	(0.728)
Population (Wales)	0.003	0.006	0.003
	(0.542)	(0.445)	(0.487)
Distance	-0.052**	-0.060 **	-0.077 **
	(0.004)	(0.003)	(0.004)
Unemployment rate (Wales)	-0.082**	-0.089**	-0.083**
	(0.003)	(0.004)	(0.003)
Unemployment rate (Move-out)	0.311***	0.402***	0.367***
	(0.000)	(0.000)	(0.000)
GDP per capita (Wales)	0.078**	0.085**	0.089**
	(0.007)	(0.006)	(0.006)
GDP per capita (Move-out)	-0.014***	-0.066***	-0.056***
	(0.000)	(0.000)	(0.000)
EU free movement	-	0.869***	0.774***
	-	(0.000)	(0.000)
Covid-19	-	-	0.006*
	-	-	(0.034)
Region FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Constant	0.602***	0.663***	0.653***
	(0.000)	(0.000)	(0.000)
Observations	1998	1998	1998
\mathbb{R}^2	0.798	0.877	0.873
I-P-Shin test W[t-bar]	-3.32	-3.37	-2.58

Table 4.4 Impacts of Brexit on EU	migrants earning no	less than £30,000	per annum to Wales

Note: Consistent with the requirements of the FEVD method, the covariates of population (move-out and Wales) and distance is treated as stable variables and their standard errors are robust to heteroskedasticity. The I-P-Shin statistics reject the null hypothesis of nonstationarity. ***P < 0.001, ** P < 0.01, * P < 0.05.

Variable	Ι	II	III
Population (Move-out)	0.289***	0.236***	0.278***
	(0.000)	(0.000)	(0.000)
Population (Wales)	0.001	0.003	0.002
	(1.343)	(1.004)	(1.211)
Distance	0.021	0.023	0.037
	(1.004)	(0.993)	(0.994)
Unemployment rate (Wales)	-0.105**	-0.121**	-0.115**
	(0.003)	(0.002)	(0.002)
Unemployment rate (Move-out)	0.421**	0.453**	0.419**
	(0.005)	(0.005)	(0.004)
GDP per capita (Wales)	0.123**	0.136**	0.132**
	(0.006)	(0.005)	(0.003)
GDP per capita (Move-out)	-0.236***	-0.317***	-0.297***
	(0.000)	(0.000)	(0.000)
EU free movement	-	-0.026	-0.030
	-	(1.211)	(1.083)
Covid-19	-	-	0.003
	-	_	(2.737)
Region FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Constant	0.354***	0.366***	0.359***
	(0.000)	(0.000)	(0.000)
Observations	745	745	745
\mathbb{R}^2	0.904	0.813	0.809
I-P-Shin test W[t-bar]	-2.39	-2.50	-2.56

Table 4.5 Impacts of Brexit on non-EU migrants earning no less than £30,000 per annum to Wales

Note: Consistent with the requirements of the FEVD method, the covariates of population (move-out and Wales) and distance is treated as stable variables and their standard errors are robust to heteroskedasticity. The I-P-Shin statistics reject the null hypothesis of nonstationarity. ***P < 0.001, ** P < 0.01, * P < 0.05.

4.4.3 Robustness Tests: IV Method and Replacement Method

To test the robustness of our empirical results, we apply two robustness tests to analysis of impacts of Brexit on migration to Wales based on categories of earnings (Tables 4.6 and 4.7).

First, Table 4.6 shows results of the same regression process to examine such impacts by replacing the original LFS data with NINo (national insurance number) data to measure the number of labour migrants to Wales. As is shown in this table, coefficients of EU free movement are significantly positive for EU labour migrants with all categories of earnings, indicating that abolishment of EU free movement rights to the UK has significant causal effects on reduction of EU migrants to Wales, thus our empirical results are robust.

Second, following Nicoli et al. (2022), we add three more control variables, namely total imports and exports between Wales and its trade partners, and the proportions of the tertiary sector in Wales and origin countries of migration to Wales. Total imports and exports reveal the

trade volumes between Wales and its counterparts while the proportions of the tertiary sector represent different industrial structures. Table 4.7 shows results of the second robustness test and can prove that our empirical results are feasible.

Variable	Migrants to Wales (data source: NINo)						
	(1)	(2)	(3)	(4)	(5)	(6)	
EU free movement	0.532***	0.674**	0.897**	0.773***	-0.004	-0.034	
	(0.232)	(0.003)	(0.008)	(0.020)	(1.676)	(1.003)	
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	
Observations	689	689	1,998	1,998	745	745	
<i>R</i> ²	0.756	0.746	0.608	0.832	0.767	0.804	

 Table 4.6 Robustness Test 1 (Replacing data sources of the dependent variable)

Note: Consistent with the requirements of the FEVD method, the covariates of population (move-out and Wales) and distance is treated as stable variables and their standard errors are robust to heteroskedasticity. ***P < 0.001, ** P < 0.01, * P < 0.05.

Variable	Migrants to Wales (data source: LFS)						
v anabie	Wigrants to Wales (data source. Ers)						
	(1)	(2)	(3)	(4)	(5)	(6)	
EU free movement	0.042***	0.084***	0.146**	0.178**	-0.021	-0.032	
	(0.032)	(0.993)	(1.224)	(0.561)	(1.278)	(0.087)	
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	
Observations	689	689	1,998	1,998	745	745	
<i>R</i> ²	0.706	0.805	0.862	0.798	0.808	0.755	

Table 4.7 Robustness Test 2 (Adding control variables)

Note: Consistent with the requirements of the FEVD method, the covariates of population (move-out and Wales) and distance is treated as stable variables and their standard errors are robust to heteroskedasticity. ***P < 0.001, ** P < 0.01, * P < 0.05.

4.4.4 Forecast: Future Impacts of Brexit on Migration to Wales

The Welsh version of NiGEM model and database are utilised to perform the short-term forecast of migration to Wales for 2023 to 2027. The theoretical foundation of the forecast is based on the FEVD gravity model demonstrated in previous sections. However, the forecast assumes that Brexit will not be overturned, namely that there will not be another referendum

that decides the UK returning to the EU in next five years. Additionally, the forecast assumes a long-lasting lag effect of the Covid-19 pandemic and the Ukrainian War given that impacts of both of them on the UK economy and migration are estimated to continue for a long period. The exclusive NiGEM regression and forecast software is used during the process of forecast with authorization from the National Institute of Economic and Social Research and Cardiff University.



Figure 4.5 Estimations of future migration to Wales, in thousands, 2023-2027

Note: 1. The EU (in total) represents the estimation of all EU migrants to Wales including employed and unemployed migrants based on the historical data of all EU migrants to Wales. 2. Categorized data of EU migrants earning no less and less than £30,000 per annum is used to make the forecast of migrants in these two categories.

Figure 4.5 shows estimations of EU and non-EU migrants to Wales in 2023-2027. Specifically, the number of total EU net migrants including employed and unemployed (students, dependents, retirees, etc) migrants is estimated to decrease by 19.17% until 2027. Trends of EU migrants with different income levels are expected to diverge, indicating a 14.67% increase in EU migrants earning no less than £30,000 per annum and a 72.5% of decrease in EU migrants earning less than £30,000. In several other studies, such as Botterill et al. (2019), the heterogeneity in the process of labour migration's response to Brexit with divergent income levels is also noted. Non-EU migrants earning no less than £30,000 per annum are expected to increase by 48.9% in five years to 2027, reaching around 67,000 in 2027 and close to the number of total non-EU migrants (around 97,000).

These findings are similar to estimations of future net migration to Wales conducted by Portes & Forte (2019) that forecast a 75% decrease in the number of net EU migrants earning less

than £30,000 and a 20% increase in the number of non-EU migrants earning no less than £30,000.



Figure 4.6 Spatial heterogeneity of estimations of EU migrants to Wales, 2023-2027

Note: Author's elaboration based on estimations of EU migrants to Wales during the given period by local council.

Figure 4.7 Spatial heterogeneity of estimations of non-EU migrants to Wales, 2023-2027



Note: Author's elaboration based on estimations of non-EU migrants to Wales during the given period by local council.

Figures 4.6 and 4.7 interpret the spatial heterogeneity of estimations of EU and non-EU migrants to Wales from 2023 to 2027, based on the NiGEM forecast. Estimations of migrants categorised by income levels are not applicable due to data availability. Both EU and non-EU migrants are more likely to migrate to south Wales which is the economic centre of Wales while migration to southwest Wales also occupies a large proportion among EU migrants. More specifically, Cardiff and Swansea are estimated to witness annual increase rates of 5.8% and 5.6% of EU migrants in next five years, respectively. The two regions that are estimated to have the highest annual increase rates of non-EU migrants are, however, Cardiff and Newport, with the figure being 6.4% and 6.0%, respectively. The education-migration industry has the potential of encouraging more non-EU migrants than other industries (Bass, 2019) and more broadly speaking, the service sector including education, retail, entertainment, and finance can absorb more international migrants than other industries (Fassio et al., 2019). Cardiff has been the economic and industrial hub in Wales and embraces most non-EU migrants in Wales in past decades with a focus on the service sector such as education and finance. Newport, which is bordered by Cardiff, might act as a bed town for international migrants to purchase properties and live.

4.5 Discussions

4.5.1 Potential Mechanism I: International trade

Trade and migration between two countries are usually procyclical, showing that a closer trade relationship could lead to more cross-border migrants (Helliwell, 1997). Egger et al. (2012) analyse trade and migration between the US and Mexico and also point out that cross-border migration between two countries is positively correlated with the trade volume between them. Tombe and Zhu (2019) find that in countries with vast territories such as China, internal trade and interprovincial migration also demonstrate significantly positive correlations, indicating that the interprovincial migration usually happens between two provinces with strong ties of trade. There are several potential mechanisms through which trade and migration between two regions show a procyclical feature. First, frequent import and export connections will lead to the growing demand for exchange of technology, capital, and labour between two regions, which encourages increase in bilateral migration (Hatzigeorgiou & Lodefalk, 2015). Second, the growing migration will contribute to an increasing demand for goods exchange, which can lead to increase in imports and exports (Sgrignoli et al., 2015). Thus, it is important to analyse whether the Wales-EU trade acts as a mechanism connecting migration to Wales and Brexit.

As is discussed in previous sections, Wales has kept a close trade relationship with EU countries and remains one of the most important trade partners of the EU among all UK countries. In addition, taking advantage of the globalisation of both secondary and tertiary sectors, Wales has become an important trade partner of non-EU countries such as Japan, India, and China. For instance, Hitachi, a major Japanese manufacturing company, has maintained frequent business connections with Wales and encouraged trade of industrial products between Wales and Japan³². Clothes, toys, and smart phones made in China with Chinese brands have formed an important part of the commodity market in Wales. During the period from the 2016 Brexit Referendum until the end of Brexit transition period in 2020, there were no new free trade agreements signed by the UK and its non-EU trade partners (Freeman et al., 2022), indicating that Brexit is unlikely to have significant impacts on trade between Wales and its non-EU counterparts. Meanwhile, Brexit is expected to only affect trade between the UK and the EU by forcing the UK to organise individual free trade negotiations with each EU member state while trade agreements between the UK and non-EU trade partners are irrelevant to Brexitrelated trade shocks (Du et al., 2023). Thus, it is feasible to mainly focus on the trade between Wales and EU countries before and after Brexit as an intermediate which connects Brexit and migration to Wales. However, considering that non-EU trade still occupied high proportions in

³² https://www.business-live.co.uk/economic-development/worlds-first-rail-testing-centre-26721575

the total international trade volume of Wales, we also included the analysis on potential impacts of Brexit on the trade between Wales and non-EU countries.

The ONS data of import and export between Wales and its EU and non-EU trade partners during the sample period, 2000-2022, is utilised to proceed the mechanism test. To perform the regression analysis, we use the variable $Trade_{it}$ to represent the total value of imports and exports between Wales and its trade partner, country *i*, at time *t*. Then, the mechanism variable, $Trade_{i,t} \times R_{i,t}$ is created to measure the potential impacts of negative perceptions brought by 2016 Brexit Referendum on trade between Wales and its trade partners, where $R_{i,t}$ is a dummy variable which equals to 0 after 2016 and equals to 1 in and before 2016. As is discussed before, numerous studies reveal that the 2016 Referendum resulted in negative expectations of trade between the UK and other countries, which might discourage international trade for the UK. We believe it is feasible to choose 2016 as the turning point to examine potential impacts of Brexit on Wales-EU and Wales-non-EU trade and then further discuss the mechanism of trade in correlations between Brexit and migration to Wales.

As a result, the model for this mechanism test is shown as follows.

$$M_{i,j,t} = \beta_0 + \beta_1 R_{i,t} + \beta_2 Trade_{i,t} \times R_{i,t} + \beta_3 X_{j,t} + \beta_4 X_{i,t} + \varepsilon_{i,j,t}$$
(7)

where $X_{j,t}$ includes all control variables of the Welsh economy and $X_{i,t}$ represents all control variables of the economy of each move-out country. The fixed effect approach is used to analyse this potential mechanism and results of regression analysis are demonstrated in Tables 4.8.1 and 4.8.2.

Variable	Ι	II	III
R _{i,t}	0.072***	0.087**	0.082
	(1.243)	(0.098)	(0.038)
$Trade_{i,t} \times R_{i,t}$	0.055**	0.048**	0.005
	(0.323)	(0.003)	(0.021)
$D_{i,j}$	-0.006	-0.076	-0.007
	(3.231)	(0.245)	(0.989)
$U_{j,t}$	-0.005	-0.012	-0.005
	(0.348)	(0.043)	(1.002)
$U_{i,t}$	0.565**	0.533***	0.422***
	(1.321)	(0.054)	(0.547)
$G_{i,t}$	0.043**	0.032**	0.005
	(0.006)	(0.325)	(-0.004)
$G_{i,t}$	-0.057**	-0.132**	-0.165***
	(0.778)	(0.036)	(1.212)

 Table 4.8.1 Results of mechanism test I: Wales-EU trade

Region FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Constant	0.443***	0.464***	0.423***
	(0.045)	(1.248)	(0.049)
Observations	689	1998	745
\mathbb{R}^2	0.797	0.802	0.815

Notes: */**/** indicates the difference in means between the two groups is statistically significant at the 0.1/0.05/0.01 level, and the standard errors of robustness are in parentheses.

Table 4.8.2 Results of	f mechanism	test I:	Wales-	non-EU	trade
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Variable	Ι	II	III
R _{i,t}	0.076***	0.076**	0.013
	(0.343)	(0.321)	(0.004)
$Trade_{i,t} \times R_{i,t}$	0.035	0.028	0.011**
	(0.204)	(0.034)	(0.021)
$D_{i,j}$	-0.003	-0.006	-0.003
	(0.056)	(1.455)	(0.005)
$U_{j,t}$	-0.027	-0.005	-0.008
	(0.077)	(0.041)	(0.992)
$U_{i,t}$	0.503**	0.509***	0.426**
	(0.783)	(1.112)	(0.783)
$G_{j,t}$	0.006	0.012	0.011
	(0.346)	(0.056)	(1.288)
$G_{i,t}$	-0.043**	-0.079**	-0.101***
	(0.088)	(0.123)	(0.877)
Region FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Constant	0.421***	0.425***	0.424***
	(0.004)	(0.883)	(1.005)
Observations	689	1998	745
\mathbb{R}^2	0.734	0.726	0.776

Notes: */*/** indicates the difference in means between the two groups is statistically significant at the 0.1/0.05/0.01 level, and the standard errors of robustness are in parentheses.

It is important to note that Columns I, II, and III in both tables above represent regression results for EU migrants with annual income lower than £30,000, EU migrants with annual income higher than £30,000, and non-EU migrants with annual income higher than £30,000, respectively. Table 4.8.1 shows results of the potential mechanism of Wales-EU trade and its impacts on the correlations between Brexit and migration to Wales. It shows that the free movement right captured by $R_{i,t}$ has significantly negative correlations with migration to Wales for both categories of EU migrants while it seems to have had no impacts on non-EU migrants to Wales. Coefficients of the mechanism variable indicate that fluctuations in Wales-EU trade might have amplified the negative impacts of Brexit on EU migration to Wales. Table 4.8.2 also highlights the mechanism of trade that amplifies non-EU migration to Wales since the coefficient of the mechanism variable is significantly positive. Meanwhile, since the coefficient of free movement is not significant in Table 4.8.2, it might be more feasible to claim that the increasing value of trade between Wales and non-EU countries itself mainly contributed to the increase in non-EU migrants to Wales. We consider it as an important finding which reveals international trade between Wales and its trade partners as an amplifier that have additional stimulation to impacts of Brexit on migration to Wales. It is also consistent with multiple studies that have justified the procyclical amplification effect between trade and international migration (Helliwell, 1997; Tombe & Zhu, 2019).

4.5.2 Potential Mechanism II: EU-related firms in Wales

Firms are one of the most significant participants in every economy and usually embrace most of labour migrants in each move-in country (Maskell, 2001). Considering the large proportion of jobs for international migrants created by firms, we further performed another mechanism test which focuses on whether the number of EU-related firms in Wales can be considered as a proxy which intermediates between Brexit and migration to Wales. Since it has been made clear that non-EU migration to Wales was hardly affected by Brexit, we concentrate on impacts of Brexit on EU migration and endeavour to discuss whether the number of EU-related firms in Wales can perform as an intermediate that amplifies negative impacts of Brexit on migration to Wales especially from the EU. Taking advantage of the FAME database, we extracted the data of the number of EU-related firms in Wales from 2000 to 2022 with details of countries of ownership for each EU-related firm, which meets the requirements of panel data analysis and is also consistent with the fact that the EU experienced rounds of expansion with several more members for each round of expansion. It is represented by the variable $EUF_{i,t}$, showing the number of firms in Wales that belonged to EU country *i* at time *t*. Other variables are the same as in Equation (7). The turning point is also 2016, the same as in the first mechanism test, demonstrated by the free movement dummy variable. Thus, the model for this mechanism test is constructed, shown as below Equation (8).

$$M_{i,j,t} = \beta_0 + \beta_1 R_{i,t} + \beta_2 EUF_{i,t} \times R_{i,t} + \beta_3 X_{j,t} + \beta_4 X_{i,t} + \varepsilon_{i,j,t}$$
(8)

Results of the mechanism test is shown in Table 4.9. To focus on the core independent variable, i.e., $R_{i,t}$, we omitted results of coefficients of all control variables for all categories of migrants to Wales, i.e., for three columns.

Variable	Ι	II	III
$R_{i,t}$	0.073**	0.072**	0.011
	(1.008)	(0.034)	(0.323)

Table 4.9 Results of mechanism test II: EU-related firms in Wales

$EUF_{i,t} \times R_{i,t}$	0.027**	0.043**	0.006
	(0.992)	(0.011)	(0.455)
Region FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Constant	0.402***	0.443***	0.431***
	(0.337)	(0.056)	(-0.004)
Observations	689	1998	745
\mathbb{R}^2	0.768	0.771	0.724

Notes: */*/** indicates the difference in means between the two groups is statistically significant at the 0.1/0.05/0.01 level, and the standard errors of robustness are in parentheses.

Despite identical significance of coefficients of the free movement dummy variable, Table 4.9 further illustrates the decrease in the number of EU-related firms in Wales during the period of 2016-2022 amplified the negative impacts of Brexit and relevant perceptions on EU migration to Wales. More specifically, with the decision of Brexit coming out in 2016, the expectation of pessimistic economic and business relationship between the UK and EU and the growing risk of economic instability in the UK leads to cautious business behaviours of EU-related firms with regard to the trade in the UK market, which has further discouraged EU migration to the UK, including Wales. This finding is consistent with Portes (2022) who claims that fluctuations in the UK-EU trade might lead to more reluctance to migrate to the UK among EU migrants.

4.6 Conclusion

The main purpose of this chapter is to review the historical impacts of Brexit on migration to Wales, decompose such impacts to reveal demographic and industrial heterogeneity, and finally perform estimation of potential trends of future migration to Wales by considering the long-term effects of Brexit and other two external shocks, i.e., the Covid-19 pandemic and the Ukrainian War. It has proved that Brexit has significant negative impacts on certain groups of migrants to Wales and estimates that such impacts might continue in next five years. Specifically, it has an overall negative impact on EU migrants while does not have significant impacts on non-EU migrants to Wales. Among EU migrants, those earning less than £30,000 per annum in the construction and manufacturing industries are the group that received the most critical negative impacts from Brexit. However, non-EU migrants seem to benefit from Brexit-related restrictions on international migration, especially the migration from the EU region to the UK, by taking advantage of higher-than-average skillsets and education. By separating the data of migrants based on the threshold, this study explores how migrants with

different income levels will respond to the Brexit shock. It has revealed that migration patterns in Wales are extremely similar to those in the UK, which could encourage further analysis on impacts of migration to the UK from regional perspectives, such as analysis on migration to Scotland and Northern Ireland, providing a new region-based approach for this topic.

This chapter also provides an analytic framework for immigration policy review in the UK, which introduces approaches of subnational-level empirical analysis to expand the boundary of Brexit-related migration research by applying both the spatial fixed-effect model for historical review and NIGEM-based forecast methods. Spatial research on impacts of Brexit on migration from the rest of the world to other UK countries such as England and Scotland can benefit from approaches applied in this paper and generate a comprehensive empirical result to demonstrate impacts of Brexit on migration to the UK with a subnational foundation. Finally, it is found that declining Wales-EU trade and decreasing EU-related firms in Wales might be two potential mechanisms through which EU migrants to Wales were negatively impacted by Brexit in the past decade. For non-EU migrants to Wales, the growing total value of trade between Wales and its non-EU trade partners might have resulted in the increase in the number of this group.

The study performed in this chapter has several policy implications. First, it is vital for Wales and other UK countries which share similar strong connections with the EU to prepare for the estimated decrease in EU migrants and to design merit-based immigration policies for the demand of the labour market, which can be of great value for attracting talents and levelling up the structure of the labour market. Second, it is necessary to narrow the scale of impacts of Brexit on migration by conducting a more globalized immigration approach to attract non-EU labour migrants, which could minimize the negative impacts of declining EU migrants on the labour market and local economy of the UK. Third, local governments should prepare for potential waves of refugees from Ukraine and BNO migrants from Hong Kong given the possibility of perpetuation of the Ukrainian War and growing migration from Hong Kong.

There are also several limitations that can be solved in future research. First, due to the data availability, we have opted out a number of variables that might have influenced migration to Wales, such as firm-level TFP, income, investment, and government spending. These variables might have significant impacts on the decision to migrate to Wales and need to be further controlled for a more feasible empirical result. Second, the industrial heterogeneity can be better analysed if more data of other industries in Wales can be obtained. Third, Docquier et al.

(2011) and many other scholars have revealed that international migration demonstrates significant heterogeneity based on different levels of skills owned by migrants, indicating that migrants to Wales with different levels of skills might have been heterogeneously impacted by Brexit-related restrictions on international migration. Relevant studies on correlations between skillsets and migration to Wales require micro-level data and data-driven OLS methods, which can be a valuable supplement to this study.

Chapter 5 Impacts of Brexit on Economic Growth in Wales

5.1 Literature Review

5.1.1 Impacts of Brexit on International Trade

Numerous studies have focused on potential impacts of Brexit on international trade between the UK and its trade partners. There are several key points that require to be clarified. First, the trade between the UK and non-EU countries is believed not to be severely disrupted by Brexit since the final Brexit agreement does not involve any major changes to the UK international trade policy with regard to the trade between the UK and non-EU countries and regions. Meanwhile, although the UK started free trade negotiations with Australia, Japan, and several other countries since 2016, there have been almost no new free trade agreements becoming effective between the UK and non-EU countries from 2016 to 2022, indicating that the trade between the UK and its non-EU counterparts is unlikely to have been impacted by Brexit. Second, regarding the UK trade policy on the UK-EU trade after Brexit, it is important to note that the Trade and Cooperation Agreement (TCA) became effective on January 1, 2021, following the end of Brexit transition period³³. The TCA has structured the current and future UK-EU trade policy and states that the UK still has access to free trade in goods with the EU and limited mutual market access in services, as well as for cooperation mechanisms in a range of policy areas, transitional provisions about EU access to UK fisheries, and UK participation in some EU economic programmes. It is also essential to realise that within the framework of the TCA, the UK operates its business behaviours independently from the EU single market and customs union. This shift has led to the discontinuation of free movement of people and the establishment of a customs and regulatory boundary between the UK and EU. As a result, numerous new non-tariff barriers have emerged, such as customs inspections, sanitary and phytosanitary constraints on the trade of animal and plant products, the necessity to demonstrate regulatory compliance separately in both the UK and EU, limitations on shortterm business visits, and diminished market access for service providers, including the termination of passporting rights for financial services.

Numerous studies have noticed the significant difference in the UK-EU trade by comparing the previous membership of EU single market with the current new system of TCA. Freeman et al. (2022) point out that compared to the pre-Brexit condition of the UK-EU trade, the TCA will still discourage the UK-EU trade by introducing a number of additional suspensions, such as

³³ See Research Briefing on TCA: <u>https://commonslibrary.parliament.uk/research-briefings/cbp-9139/</u>

the suspension of free movement between the UK and EU, UK membership in the European Single Market and Customs Union, UK participation in most EU economic programmes, and part of the EU–UK law enforcement and security cooperation on economic and business exchanges. Dhingra et al. (2022) further claim that the implementation of the TCA has resulted in higher trade costs due to the re-establishment of a customs and regulatory border between the UK and the EU. Ayele et al. (2023) examine the potential negative impacts of extra tariffs on the UK-EU trade due to the TCA and find that from January to July 2021, approximately 30% of UK exports to the EU, which were eligible for preferential zero-tariff entry under the TCA, incurred extra tariffs. They also claim that to qualify for tariff-free and quota-free access according to the TCA, products need to adhere to rules of origin criteria which typically define the percentage of a product's value that must originate in either the UK or the EU to be eligible for TCA benefits. However, not all goods meet these criteria, and in certain instances, the potential tariff savings gained from meeting rules of origin may be outweighed by the costs associated with demonstrating compliance, which leads to the fact that trade between the UK and EU under the TCA might include extra tariffs compared to the pre-Brexit era.

Additionally, it should be highlighted that the 2016 Referendum might have provided business owners who operate the UK-EU trade with negative perceptual expectations of the future UK-EU trade schemes (Tetlow & Stojanovic, 2018), which makes it reasonable to consider the year of 2016 as the turning point for analysis on impacts of Brexit and its trade-related perceptual factors on the UK-EU trade. It is highly consistent with what have been discussed in Chapter 3.4.1 which reviews the current literature on impacts of the 2016 Referendum on migration to the UK based on a risk perception approach. In fact, in response to policy shocks such as Brexit, business owners might adjust their decision of international trade and business expansion more promptly than immigrants since immigrants require a longer period to prepare for changes in immigration destinations while costs for risk-averse business owners to transfer their trade destinations to less risky regions are usually smaller due to their advantages of allocating resources such as labour and capital more efficiently (Markusen et al., 1995). Thus, we believe it is important to consider 2016 as a key timepoint of treatment that decides the values of the key dummy variable that indicates the existence of Brexit-related perceptions. Following such approach, Douch and Edwards (2022) use the synthetic control method (SCM) to analyse the effects of uncertainty and anticipation shocks associated with the 2016 Referendum as a treatment on trade between the UK and 14 EU and 14 non-EU trading partners and find that policy uncertainty brought by Brexit has a major effect upon the UK-EU trade and uncertainty of supply chain costs is a potential mechanism.

Regarding impacts of Brexit on trade between Wales and its trade partners, there are few studies on this issue. Khorana and Perdikis (2018) apply the CGE model based on the Global Trade Analysis Program (GTAP) to forecast such impacts with three scenarios of trade relationship between the UK and EU, i.e., No-Deal Brexit (WTO scenario with the EU), transition-period Brexit (2, 3, 5, and 10 years of transition period), and Canada-EU style Brexit (Comprehensive Economic and Trade Agreement). They find that the impact of Brexit on the Welsh economy will be felt via reductions in the UK-EU trade, and the least costly outcome for Wales is if the status quo can be held to for as long as possible and the costliest is a Brexit based on WTO rules. However, this study might not be able to reflect the reality of one-year transition period of Brexit that we have experienced. Nevertheless, the CGE approach utilised in this study and the setting of the 1-year transition period scenario will be applied in this thesis to derive the future estimation of long-term impacts of Brexit on the trade between Wales and other countries. Dudley and Gamble (2023) also reveal that Brexit contributed to higher costs of Wales-EU trade but seems not to have significant impacts on the trade between Wales and non-EU trade partners. Except a small amount of work including two papers above, we find it extremely difficult to obtain adequate studies that analyse impacts of Brexit on Wales-EU and Wales-non-EU trade based on an econometric approach. We hope to make contributions to this field by providing empirical analysis on this issue.

To summarise, the current literature has concentrated on impacts of Brexit and its related perceptions on the trade between the UK and its trade partners, especially those belonging to the EU single market. A large proportion of these studies have been related to the comparison of the UK-EU trade between the post and pre-Brexit eras with the major difference of the UK's status in the UK-EU trade scheme, i.e., the membership of the EU single market before Brexit and the TCA after Brexit. Studies on impacts of Brexit on the trade between Wales and its counterparts are extremely insufficient. Due to data availability, our empirical analysis will adopt the 2016 Referendum as the treatment of Brexit-related perceptions of trade to analyse impacts of Brexit on trade between Wales and its trade partners.

5.1.2 Impacts of Brexit on FDI Inflow

According to the Brexit agreement between the UK and EU, the current Brexit deal primarily focuses on the UK's future relationship with the EU in various aspects, including trade, security,

and other areas. Regarding FDI, this deal does not significantly alter the general framework for foreign investment, as the UK and EU aim to maintain an open and conducive environment for foreign investors. Thus, there is no direct expression of FDI-related restrictions in the final agreement of Brexit. However, it remains to be a significant issue that Brexit might still trigger impacts on FDI in the UK, especially FDI from the EU, due to the existence of extra trade, business, and economic restrictions between the UK and EU after Brexit. The current literature on impacts of Brexit on FDI in the UK adopts two major methodologies, i.e., the policy uncertainty approach and the regime-switching methodology based on the narrative that considers Brexit as a policy shock or a regime-changing event that will affect FDI.

The first methodology to analyse this issue is the economic policy uncertainty approach which has been applied to analysing impacts of economic policy shocks on economic growth, FDI, and trade in many countries. In general, Zhang and Wang (2016) find that during periods of economic prosperity, uncertainty in economic policy tends to suppress output levels. Conversely, in times of economic depression, the effect is reversed, leading to an increase in output levels. Some other researchers contend that fluctuations in output are not caused by economic policy uncertainty but argue that economic policy uncertainty exerts a significant negative impact on price levels of products and thus leads to depreciation of values of domestic products (Tian et al., 2017). In addition to impacts of economic policy uncertainty on overall economic growth, numerous studies also reveal that such uncertainty also has repercussions on various economic factors. Claeys (2017) finds that emerging markets may experience prolonged and intensified declines in both consumption and investment as global uncertainty spreads. Utilizing the Vector Error Correction Model (VECM), Jeon et al. (2017) discover an inverse correlation between the Korean economic policy uncertainty index and other domestic economic indicators, indicating that a surge in the Korean uncertainty index predicts a deterioration in the domestic economy. Meinen and Roehe (2017) report a substantial negative impact of macroeconomic uncertainty on investment in key Eurozone countries, contributing to the decline in gross fixed capital formation in machinery and equipment during the Great Recession. Katayama and Kim (2018) highlight that heightened economic policy uncertainty not only simultaneously reduces consumption and investment but also leads to an increase in the relative prices of investment goods.

Inserting the policy uncertainty approach in the context of Brexit, we believe that Brexit represents an appearance of economic policy uncertainty or an appearance of regime-switching condition that is believed to have significant impacts on foreign direct investment (FDI) in the

UK. 12 years earlier than the 2016 Referendum, Pain and Young (2004) conducted a simulation using the National Institute model of the UK's economy (NiGEM), specifically examining the Brexit effects on the UK. By reducing fiscal transfers to the EU, their analysis revealed a decrease in foreign direct investment (FDI) and an increase in trade barriers. Irwin (2015) explored the impact of Brexit on both the UK and the EU through ten channels, including trade and FDI, determining that the economies in question would experience varying degrees of impact. Additionally, current studies conducted by scholars such as Simionescu (2016), Dhingra et al. (2018), and Jafari and Britz (2020), assert that Brexit is likely to affect macroeconomic variables in the UK such as FDI and claim that FDI from the rest of the world to the UK has been negatively impacted by Brexit. An et al. (2023) adopt the approach of economic policy uncertainty and find that impulse responses of FDI in the UK are larger than those of trade between the UK and its trade partners due to Brexit, indicating that Brexit has led to significant policy uncertainty that contributes to declining confidence in investment in the UK. Belke et al. (2018) use panel and single-country SUR estimation methods to analyse how the uncertainty led by Brexit will impact FDI in the UK and find that Brexit-induced policy uncertainty will lead to decrease in FDI from the EU to the UK with the mechanism through which the instability in key financial markets including the UK will be encouraged by Brexit. Moreover, Makrychoriti and Spyrou (2023) apply the Qual VAR model to evaluate the impact of Brexit-related uncertainty on the EU and UK economy including FDI in the UK and EU and demonstrate that Brexit is negatively correlated with FDI in the UK but seems to have resulted in increasing FDI in the EU.

The second widely-used methodology to analyse impacts of Brexit on FDI in the UK is various kinds of Markov regime-switching model. The regime-switching approach has been broadly utilised in numerous economic studies on regime-switching determinants of FDI. Bilgili et al. (2012) use a Markov regime-switching model to analyse the dynamics of FDI in Turkey with the background of external shocks and find that Turkish FDI growth equation has significant structural changes in level and trend and that has significant coefficient shifts in explanatory variables. Su et al. (2022) reveal that economic policy uncertainty due to the US-China trade conflict has significantly negative impacts on FDI inflow in China. One step further, regarding potential mechanisms of impacts of switching regimes on FDI inflow, Ning and Zhang (2018) analyse the short-term inflow of FDI in China with a Markov regime-switching model and demonstrate that fluctuations of exchange rates due to switching regimes might prove to be useful mechanism variables for detecting changes in short-term FDI inflow. Based on the

existing literature on this issue, it is feasible to summarise that domestic economic policy shocks and uncertainty can result in fluctuations of FDI inflow with two major mechanisms, i.e., the direct impacts of such uncertainty on foreign investment decisions and impacts of currency fluctuations on foreign investment motivations.

How Brexit will affect FDI inflow in the UK has also attracted a number of studies. For instance, Driffield and Karoglou (2019) focus on FDI in the post-Brexit UK and employ a Markov regime-switching structural vector autoregression model to differentiate between the fluctuating and stable phases of the economy and consider various effects, including the immediate impacts that the frequency of FDI naturally induces in the post-Brexit era. They find that a depreciation of the sterling after Brexit may positively influence FDI flows, but this impact is contingent on it leading the UK economy into a phase characterized by highly volatile growth, inflation, interest rates, and exchange rates. Meanwhile, they believe that Brexit is likely to trigger temporary sterling depreciation which will have negative impacts on FDI in the UK. Welfens and Baier (2018) apply a similar regime-switching approach and find that fluctuations of sterling values and the suspension of membership of the customs union might become two potential mechanisms through which Brexit can lead to declining FDI inflow in the UK. Oyamada (2020) points out that the UK has become less attractive to FDI, and the number of export-platforms has reduced. However, Oyamada (2020) uses a form of simulation analysis that depends on no real data with artificial variables and the imagination, which is inconsistent with what we have witnessed since 2020.

Regarding impacts of Brexit on FDI inflow in Wales, the current literature is inadequate. Khorana and Perdikis (2018), as is listed in the last section, estimate that, for the scenario of no-deal Brexit, the long-term FDI inflow in Wales will decrease by 0.03%-0.04% from 2020 to 2030 due to Brexit with an increasing rate. For the scenario of status quo after Brexit, the long-term FDI inflow in Wales will slightly increase. For the scenario of CETA-style FTA after Brexit, the long-term FDI inflow in Wales will experience a neglectable decline during the same period. Several other relevant studies consider impacts of Brexit on FDI inflow in the UK as a whole and mention such impacts in Wales as a subnation of the UK. Bachtler and Begg (2017) claim that negative correlations between FDI inflow in Wales. Fuller (2022) also reveal that Wales might suffer from declining inward FDI due to Brexit and weak regional resilience which potentially results from the close economic relationship between Wales and the EU. As is stated, there is no significant study that adopts a regime-switching model to

specifically analyse impacts of Brexit on FDI inflow in Wales, an important subnation of the UK. This study can then make an important contribution to the literature in this area.

In conclusion, the current literature focusing on impacts of Brexit on FDI inflow in the UK mainly adopts the regime-switching model and the policy uncertainty approach to analyse how FDI inflow in the UK was impacted by Brexit through potential mechanisms. Several studies also construct series of scenarios such as no-deal Brexit and Brexit with a transition period of 2, 3, or 5 years to support their results (Portes, 2018; Dhingra et al., 2016). In according with what has actually happened, this study will set up the scenario of 1-year transition period of Brexit to examine correlations between Brexit and FDI inflow in the UK.

5.1.3 Impacts of Brexit on Economic Growth

Brexit has introduced a level of uncertainty that holds the potential to disrupt the flow of goods and services between the UK and the EU. In the absence of a Free Trade Agreement (FTA) with the EU, British goods may face the imposition of the EU's common external tariffs. If the UK also implements its tariff barriers, bilateral trade could be compromised, leading to adverse effects on economic growth for both parties. This uncertainty has a broader impact by diminishing the confidence of both consumers and investors, thereby reducing aggregate demand and contributing negatively to the UK's overall economic landscape. The uncertainties surrounding potential new trade barriers for goods may act as a deterrent for FDI in the UK. This, in turn, has the potential to diminish openness and innovation, resulting in a long-term reduction in productivity within the UK.

Brexit would impact services trades as well. For instance, the "passporting" privilege, enabling the establishment of businesses freely across all EU countries, may be at risk. Additionally, if regulations within the financial sector are not aligned, there could be significant repercussions for the UK's financial services exports. Companies might consider establishing themselves in the EU or relocating to better serve the EU markets. Furthermore, the UK would encounter additional obstacles in third-country markets where preferential access was lost due to Brexit, and negotiating new trade deals would be a time-consuming process. The anticipated savings from halting net transfers to the EU are relatively modest, amounting to only about 0.3%–0.4% of GDP per year. Finally, since 2005, immigration has contributed to half of the UK's GDP growth, leading to the creation of over 2 million jobs (Jafari & Britz, 2020). As such, restricting immigration from the EU would consequently have a detrimental impact on the UK's economic growth.

To what extent will Brexit have impacts on the UK's overall economic growth has become one of the most important issues with regard to Brexit and its potential spillover effects in the UK and has attracted plentiful attention. To measure the economic growth in the UK, the majority of existing relevant literature uses GDP (or GDP per capita) as the main measurement (See Figure 3.1). For instance, Giles (2016) presented findings from seven studies, where six indicated a trend of slower growth, except for one that showed the opposite. Within the group of slower growth studies, both LSE (Dhingra, Ottaviano, Sampson, & Van Reenen, 2016) and HM Treasury (HM Government, 2016) reported reductions exceeding 7%; the OECD (Kierzenkowski, Nigel, Rusticell, & Zwart, 2016) indicated around a 5% reduction. The remaining three studies, namely CBI/PWC (PwC, 2016), NIESR (Ebell & Warren, 2016), and Oxford Economics (2016), suggested approximately a 3% reduction each. In addition, Hantzsche et al. (2019) evaluate potential changes in trade, migration, foreign direct investment, productivity, and contributions to the EU budget by comparing existing proposals with historical evidence and further estimate future impacts of Brexit on these macroeconomic variables by using the NiGEM model. They find that should the UK government's proposed Brexit deal be enacted, the long-term GDP per capita is anticipated to be approximately 3% lower compared to what it would have been if the UK remained in the EU. If the UK were to remain in a customs union with the EU or if the Irish backstop position were to be activated, there would still be an impact on GDP per capita, albeit to a lesser extent of 2%. McCombie and Spreafico (2018) utilise a regional balance-of-payments growth constrained model and estimate that Brexit will result in declining GDP per capita in the UK and the regional disparity of GDP per capita inside the country will be enlarged due to Brexit.

More recently, Springfield (2022) conducts a state-of-the-art research on reviewing actual impacts of Brexit on the UK economy based on the historical data and the synthetic method which constructs an artificial UK that remains to be a EU member, and finds that the UK GDP was over 5% smaller than the GDP of the artificial UK in 2020 and 2021 and the major contributor of such gap is Brexit instead of the Covid-19 pandemic due to the UK becoming the first developed country that suspended all Covid-19 restrictions. As such, decomposing impacts of Brexit and the pandemic on the UK economic growth has become another significant issue among economists since the outbreak of the pandemic. Ellington et al. (2022) adopt a revised VAR model recently developed by Lenza and Primiceri (2022) to decompose the effects of Brexit and the pandemic on the UK economic growth and find that Brexit had a contracting influence on the growth of the UK's GDP, leading to notable repercussions in the

UK's financial markets, such as heightened long-term borrowing costs and increased volatility in exchange rates. They also reveal that an economic policy uncertainty shock such as Brexit triggers a statistically significant and contractionary impact on UK GDP growth for as many as twelve months. Meanwhile, such contractionary effect can only be identified if the outliers in macroeconomic and financial data brought by the pandemic are appropriately accounted for in their empirical model. McCann et al. (2023) highlight the potential larger gaps in regional economic growth across different regions in the UK due to the combined spillover effects of Brexit and the pandemic and specifically raise awareness of economic depression impacted by these spillover effects in several left-behind regions in Wales and England.

In conclusion, according to existing literature, there are several channels through which impacts of Brexit can be imposed on the UK economic growth. First, Brexit will have impacts on the UK economy through the mechanism of trade, which is discussed in previous sections. Second, the UK economic growth might be affected by Brexit due to fluctuations in migration to the UK since international migration has become one of the most important economic drivers for the UK economy. Third, Brexit might lead to changes in FDI inflow to the UK, which will further result in variations in the UK economic growth.

Thus, it is clear that migration to the UK, trade between the UK and its trade partners, and FDI inflow in the UK are three major mechanisms through which Brexit can affect the UK economic growth while discussion on these mechanisms have already been provided in previous chapters. Regarding impacts of Brexit on the Welsh economy, Khorana et al. (2020) utilize a dynamic simulation model based on computable general equilibrium (CGE) to examine the effects of Brexit on the economy of Wales with three scenarios, no-deal WTO based Brexit and Brexit with a transition period of 2, 3, 5, or 10 years. They find that the scenario of no-deal WTO based Brexit generates maximum losses for Wales in the long-term, and a transition period arrangement projects long-term losses for Wales that depend on the length of transition period such that a longer transition minimises losses for Wales. Except this research by Khorana et al. (2020), there is a lack of relevant studies that examine to what extent has Brexit impacted the Welsh economy. As a result, this thesis aims to fill this gap in the field of subnation-level economic analysis of Brexit by adopting several advanced methodologies that have been introduced in previous sections.

5.2 Hypotheses

Section 5.1 has comprehensively discussed the current literature and research logics on the economic impacts of Brexit in the UK, especially on three major dimensions: international trade, FDI inflow, and local economic growth. Following discussions in the previous section, we can reasonably propose the following hypotheses to be examined in this study:

(1) Brexit had impacts on international trade between Wales and its trade partners and FDI inflow from both EU and non-EU countries to Wales.

(2) Such impacts, along with impacts of Brexit on migration to Wales, have become potentially major mechanisms through which the overall Welsh economy measured by GDP per capita was impacted by Brexit.

5.3 Data

To further proceed with empirical analysis on impacts of Brexit on international trade between Wales and its trade partners, FDI inflow in Wales, and the economic growth in Wales, this chapter aims to complete two major procedures of data preparation, i.e., data description of selected variables and data patterns showing the historical trend of these variables. In this chapter, main features of selected datasets will be described and demonstrated to prepare for the section of empirical analysis.

5.3.1 Data Description

5.3.1.1 Trade

In this section of analysing impacts of Brexit on trade between Wales and other countries, we mainly focus on goods trade for two reasons. First, historical data of trade between Wales and its counterparts reveals that goods trade has occupied over 85% in the total trade values for Wales. Second, the data availability of services trade for Wales is extremely poor, making it impossible to conduct research on impacts of Brexit on services trade for Wales.

The HM Revenue and Customs (HMRC) database provides the data of goods trade between UK and its counterparts and contains transaction-level information on trade in goods. These data are gathered for administrative and taxation purposes, serving as the foundation for HMRC's 'Overseas Trade Statistics' (OTS) publication which becomes the major data source of trade between Wales and its trade partners. ONS Trade in Goods statistics release is based on these data, incorporating adjustments to ensure consistency with National Accounts and including subnational data of trade for Wales, England, Scotland, and Northern Ireland. These extensive datasets encompass a significant portion of trade in goods transactions between
Wales and its trade partners spanning the sample period from 2010 to 2022 and include three distinct types of transactions.

- (1) Transactions between businesses in Wales and EU countries. Data regarding the total value of trade in goods transactions conducted by UK businesses is gathered through the VAT returns submitted by these businesses. If the monthly value of such trade surpasses a specified administrative threshold, the business is incorporated into the monthly 'Intrastat' survey for the subsequent twelve months. According to current legislation, this survey must cover a minimum of 93% of UK imports from the EU ('arrivals') and 97% of UK exports to the EU ('dispatches'). The threshold for inclusion adjusts in response to changes in the trade value and is updated on a calendar year basis. Those participating in the survey are obligated to submit returns by the 21st day of the month following the transaction, and non-compliance may result in legal consequences, including potential criminal proceedings.
- (2) Transactions between businesses in Wales and non-EU countries. These data are acquired via the customs import and export declarations submitted by businesses in the UK including Wales, primarily processed through the Customs Handling of Import and Export Freight (CHIEF) system. These data, being administrative in nature, are not obtained through a survey and encompass a significant share of Wales trade with non-EU countries. Trade data between the Wales and its non-EU counterparts has become an important branch in the total international trade for Wales especially amid the rapid development of globalisation. Meanwhile, the trade connections between the UK including Wales and non-EU countries have been highlighted after Brexit in order to seek for alternative trade markets and destinations and make up potential loss in the UK-EU trade relationship due to Brexit.
- (3) *Estimates of aggregate trade missing from two categories above*. Summarized approximations include figures for businesses that fall below the Intrastat reporting threshold, estimations for incomplete or absent returns from businesses, and adjustments to account for Missing Trade Intra-Community (MTIC) VAT fraud. Trade data missing from two categories above is replaced with estimates.

. In specific trade instances, we possess volumetric estimates for a particular trade flow, information on whether a third party facilitated the trade, and the rationale behind the trade. Additionally, we record details about the terms of delivery, including the currency of the invoice (for non-EU trade), ancillary costs, and delivery charges (for EU trade). Information

about the reporting process is also noted, including whether a business amended its original submission. The HMRC dataset aggregates declarations from the same business with common fields; although not strictly transaction-level data, no information loss occurs in this process.

In order to measure Brexit and its relevant perceptual impacts on the trade between Wales and its trade partners, especially between Wales and EU countries, we choose the sample period of 2011Q1-2022Q4 for 12 years with 2016Q2 (the 2016 Referendum) and 2021 Q1 (the end of transition period) as the key turning points that indicate potential impacts of Brexit on trade. During this sample period, there are 152 countries having trade relationships with Wales in total, which gives us 7,296 samples of trade data measured by the total values of imports and exports between Wales and all trade partners.

In addition, we utilise the ONS data of UK goods trade by industry, country, and commodity to prepare for the robustness test of impacts of Brexit on Wales trade. It is important to note that HMRC's statistical releases adhere to the Overseas Trade Statistics (OTS) framework, as outlined in the United Nations' International Merchandise Trade Statistics Concepts and Definitions (IMTS). In contrast, ONS trade data follow a Balance-of-Payments framework, which is founded on the International Monetary Fund's Balance of Payments and International Investment Position Manual. Distinctions between these measurement bases encompass variations in coverage, recording time, valuation, and classification. The key conceptual disparity lies in the fact that OTS data aims to capture all goods transactions influencing a country's material resource stock by entering (imports) or leaving (exports) the economic territory, whereas Balance-of-Payments data is structured around the change in ownership principle. For more detailed information, please refer to the HMRC³⁴ and ONS³⁵ websites. Thus, ONS trade data for Wales becomes a feasible data source for the robustness test which replaces the data source of the dependent variable, i.e., trade.³⁶

Main data source for trade data between Wales and all foreign countries from 2011Q1 to 2022Q4 is the HMRC UK Trade Info website (regional trade data)³⁷ which includes the data of total trade volumes of all commodities between Wales and all foreign trade partners. By selecting three rows of customised data, i.e., UK Region=Wales, Country=each trading partner, and SITC=All, it will show results of export and import volumes between Wales and each

³⁵ <u>https://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/methodologies/balanceofpayments</u>

³⁴ https://assets.publishing.service.gov.uk/media/6123ce008fa8f53dcb947889/OTS_Framework_Document_20210823.pdf

³⁶ Due to data availability, trade data used in this thesis covers goods only and it is just aggregate total value instead of distinguished sector-based data. I appreciate this comment, and it is a good point to include services for future analysis. ³⁷ https://www.uktradeinfo.com/trade-data/rts-custom-table/

country during a selected sample period. The author also used the method of data scraping based on Python to extract required data from this website, i.e., data of trade volumes between Wales and all trading countries during the sample period.

In terms of the VAT method to provide an additional measurement of international trade, the author tried to use the HMRC VAT data³⁸ but noticed that yearly data of VAT requires access to HMRC online service portal, and such access is only open to corporate taxpayers and business owners. Also, the author realised that VAT is collected on the UK national level instead of regional level. Thus, discussions on VAT in this section provide information of potentially additional measurement of international trade, although the restriction of data availability currently prevents the author from using VAT data. It is important to highlight that trade data for Chapter 5 mainly comes from HMRC database, as stated above.

5.3.1.2 FDI Inflow

The data of yearly FDI inflow in Wales come from the ONS database of FDI subnational estimates of the UK, which is collected until 2021³⁹. Thus, the sample period of 2010-2021 for 12 years is selected, with 2016 as the key turning point which is identical to the setting in the last section. During this sample period, by omitting missing data, there are 64 countries that have FDI inflow to Wales, indicating that the sample size is 768. Among all 64 countries, 22 are EU countries and 42 are non-EU countries, and the categorisation to examine whether the country that FDI comes from belongs to the EU is significant for our analysis on differentiating impacts of Brexit on FDI in Wales based on country of birth. It will further clarify whether Brexit has imposed more significant impacts on EU-related FDI than non-EU-related FDI to Wales.

The main source of information for FDI statistics in Wales is the Annual FDI Survey⁴⁰ and separate surveys are used to collect data on inward and outward FDI. This is combined with data from the Bank of England for all monetary financial institutions, such as banks, and other sources for property and public corporations in FDI. Survey responses are used to estimate or impute FDI values for every company in the UK's inward and outward FDI populations. Since 2020, a new commercial data source has been used to inform the inward and outward FDI populations. These experimental estimates link FDI responses to subnational corporate

³⁸ https://www.gov.uk/government/statistics/value-added-tax-vat-annual-statistics

³⁹ <u>https://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/bulletins/foreigndirectinvest</u>

⁴⁰ <u>https://ons.metadata.works/browser/dataset?id=315</u>

information from the commercial data source, the Inter-Departmental Business Register (IDBR) and the Business Register and Employment Survey (BRES).

5.3.1.3 Economic Growth

GDP per capita is used to measure the overall economic growth of Wales and ONS database provides the data of GDP per capita in Wales. Due to data availability, the sample period is selected to be from 2010 to 2021 with 2016 being a key turning point to measure impacts of Brexit on the Welsh economy using the measurement of GDP per capita.

The Global Trade Analysis Project (GTAP) database is a comprehensive global economic dataset and provides detailed data on international trade, production, consumption, and bilateral trade flows across multiple sectors and regions. GTAP integrates national accounts, inputoutput tables, and trade statistics, covering both goods and services. The database supports policy analysis on trade agreements, environmental policies, and global economic trends. It is widely used by researchers, policymakers, and international organizations to assess the economic impacts of trade policies, climate change, and structural changes in the global economy. In terms of regionalisation of data, GTAP database is limited by the availability and quality of local data since GTAP primarily relies on national input-output (I-O) tables, trade data, and macroeconomic statistics, meaning its measurements are mainly national-level instead of regional-level.

Furthermore, the GTAP database is used to improve the feasibility and accuracy of the data of macroeconomic variables in Wales and to gather data of control variables, i.e., GDP per capita, unemployment rate, FDI, inflation rate, and exchange rate with US dollar in all other available economies. The GTAP database undergoes regular updates through the incorporation of World Bank macroeconomic data and the GTAP Adjust tool (Horridge, 2011). This database models the global economy with 140 regions and 57 economic sectors spanning the years 2004, 2007, and 2011 (Narayanan, Aguiar, and McDougall, 2015). It encompasses bilateral trade in goods and services, intermediate inputs across sectors, and government-imposed taxes and subsidies. The Input-Output Tables provided by the GTAP database are adjusted to the common reference years of 2004, 2007, and 2011 using macroeconomic aggregates such as GDP, private consumption, government consumption, and investment. The primary data source for macroeconomic information in GTAP 11 is the World Bank World Development Indicators, and reconciled bilateral merchandise trade data, derived from the United Nations Commodity

Trade Statistics database, is utilized. Regional aggregation is carried out for Wales, Rest of the UK, Rest of the EU, and the Rest of the World.

More empirically, the GTAP 11 database used in this chapter is built around a standardized set of 251 countries, enabling greater regional flexibility during data construction. To support this flexibility, international data contributors are encouraged to provide data at the country level rather than pre-aggregating it into GTAP regions. This approach allows for modifications in regional classifications without requiring new data submissions. The contributed data is mapped to the standard country set, which is then aggregated into GTAP regions based on a mapping file that is updated when new regions are introduced. The country selection ensures comprehensive economic coverage, with GDP estimates used as scaling factors for composite regions. More information regarding to data construction and quality can be found in GTAP manual: https://www.gtap.agecon.purdue.edu/uploads/resources/download/12125.pdf.

In terms of issue of local data, i.e., data of GDP per capita and control variables in Wales, the author used ONS data of regional economic activity by gross domestic product, UK: 1998 to 2022⁴¹, which covers the data required in this chapter. To enhance regional flexibility, the GTAP 11 database, used in this chapter, includes a standardized framework encompassing 251 countries. This standardized country set allows for greater adaptability during data construction by enabling researchers to refine regional classifications without requiring entirely new data submissions. The database relies on a systematic mapping process, wherein country-level data provided by international contributors is aggregated into GTAP regions based on an evolving classification framework. GDP estimates serve as scaling factors for composite regions, ensuring comprehensive economic representation.

In the context of Brexit, GTAP provides a robust framework for assessing the macroeconomic effects of trade policy changes, including their impact on regional GDP in Wales. Given that Brexit has reshaped trade relations between the United Kingdom and its key trading partners, the GTAP framework facilitates counterfactual simulations to evaluate how alterations in trade barriers, tariffs, and market access conditions affect regional economic performance. While GTAP's national-level structure poses challenges for direct regional analysis, adjustments through sectoral and subnational modelling techniques—such as regionalized I-O tables and

41

https://www.ons.gov.uk/economy/grossdomesticproductgdp/bulletins/regionaleconomicactivitybygrossdomestic productuk/1998to2022

trade elasticity estimates—can provide valuable insights into the localized effects of Brexit on Welsh economic trajectory.

Finally, to implement the estimation of long-term impacts of Brexit combined with several other shocks such as the Covid-19 pandemic and the Ukrainian War, NiGEM database is used to conduct the NiGEM forecast. The NiGEM database includes data of around 6,000 variables and over 10,000 model equations to provide essential data of all relevant independent variables for estimation of specific projects or events' economic impacts. The Welsh-version NiGEM database also includes data of around 4,000 variables and over 7,000 equations given that the Welsh economy is considered a small open economy. Key agents in the Welsh-version NiGEM settings are households, firms, governments, and monetary authorities, including agents of the Welsh economy, namely households, firms in Wales, the Welsh government, and the UK monetary authority due to Wales being a part of UK. Major variables in each agent are: 1) consumption, labour supply, income, and investment for households; 2) capital, labour demand, energy demand, and investment for firms; 3) taxation, public expenditure, and debt for governments; 4) interest rates and exchange rates for monetary authorities.

5.3.2 Data Patterns

5.3.2.1 Trade

International trade forms a significant branch of economic growth in the UK. Figure 5.1 shows the historical trends of total imports and exports during 1997-2022. In 2022, the total value of imported goods surged by £155.5 billion, marking a significant 32.3% increase compared to 2021. Furthermore, this figure exhibited growth when contrasted with the data from 2018. Throughout the year 2022, there was a consistent and notable rise in the import of goods, with substantial increases observed from both European Union (EU) and non-EU countries. The total value of goods exports surged by £66.2 billion (20.8%) in comparison to 2021. Exports to both European Union (EU) and non-EU nations demonstrated consistent growth over the course of 2022. In January 2022, there was a temporary sharp decline in EU exports due to an operational adjustment enacted by HMRC. Nonetheless, it's important to note that this decline only impacted the data for January, and subsequently, UK exports to the EU steadily increased throughout the remainder of 2022. As such, Brexit seems not to have affected total imports and exports between the UK and its trade partners.

Figure 5.1 UK total imports and exports, in £m, 1997-2022



Source: Dataset of UK international trade time series, ONS; Database of UK international goods and services trade, HMRC.

Figures 5.2 and 5.3 show major trade partners of the UK in 2022. Except the US and China, the EU is still the most important trade partner of the UK, and the trade between the UK and EU occupied 48% of total value of imports and 43% of total value of exports for the UK in 2022. In fact, the author's calculations also reveal that in the past decade (2012-2022), the UK-EU trade has occupied 52% of total value of imports and 47% of total value of exports for the UK, and since 2016 both proportions decreased by 5.6% and 6.7%, respectively. It shows that the EU remains influential in international trade of the UK and Brexit contributed to the relatively shrinking patterns of the UK-EU trade.



Figures 5.2, 5.3 Imports (left) and exports (right) with top 5 trade partners, in £m, UK

Source: ONS and the author's calculation based on existing ONS estimates of time-series trade data.

Furthermore, regarding the historical trends and gaps of UK international trade between with EU and non-EU trade partners, Figures 5.4 and 5.5 demonstrate the most up-to-date data (in 2022) of UK international trade provided by ONS⁴². It can be found that:

⁴² See ONS page: <u>https://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/datasets/uktraderecordssheet</u>

- (1) Goods trade: Despite stricter regulations on the EU side of the border, UK imports of goods from the EU have experienced a more significant decline than UK exports of goods to the EU. In the fourth quarter of 2021, goods imports from the EU saw an 18% decrease compared to 2019 levels, which is twice the 9% decrease in goods exports to the EU. The decline in EU imports is particularly notable when contrasted with the 10% increase in goods imports from non-EU countries, indicating a degree of substitution between them. Nevertheless, there is little indication, as of now, that UK goods exports to non-EU countries are compensating for the reduced exports to the EU, as the former have dropped by 18% compared to 2019 levels.
- (2) Services trade: The decline in UK services trade with the EU has been more pronounced compared to non-EU trade when measured against 2019 levels. However, a substantial portion of this reduction is likely attributable to the pandemic's impact, especially in sectors like travel and transport, which constituted a larger share of pre-pandemic EU services trade than non-EU trade. Although UK service exports to both the EU and the rest of the world have rebounded to approximately 5% and 10% below 2019 levels, respectively, imports of services from the EU continue to experience a decline of over 30%.



Figures 5.4, 5.5 Time-series changes in UK goods and services trade

Source: ONS and the author's calculation based on existing ONS estimates of time-series trade data.

Focusing on goods trade between Wales and its trade partners, in 2022, the total value of goods imports into Wales amounted to ± 24.1 billion, showcasing a substantial increase of ± 8.0 billion (49.3%) when contrasted with the figures from 2021. Furthermore, when compared to 2019, there was also a notable rise of ± 5.9 billion (32.3%) in imports. The total value of goods exports from Wales reached ± 20.5 billion, marking a substantial increase of ± 5.3 billion (34.9%) when compared to 2021. Additionally, in comparison to 2019, there was a noteworthy growth of ± 2.8

billion (15.5%) in exports. Figures 5.6 and 5.7 shows the historical trends of goods imports and exports from 2013 to 2022, respectively. Regarding goods imports, imports from the EU remained on a relatively lower level compared to those from non-EU regions, while imports from non-EU trade partners formed a dominant power to decide trends of goods imports to Wales. Regarding goods exports, more goods were exported to EU countries than non-EU countries from Wales, while goods exports to both regions shared similar patterns during this period. As such, Brexit seems not to have imposed negative impacts on both imports and exports with both EU and non-EU trade partners of Wales.





Figure 5.7 Total goods exports, in £bn, Wales, 2013-2022



Source: Regional Trade in Goods Statistics, HM Revenue & Customs.

5.3.2.2 FDI Inflow

According to EY 2023 UK Attractiveness Survey⁴³, in 2022, the UK was home to 929 foreign direct investment (FDI)-backed projects, which represented a decrease of 6.4% compared to the 993 projects recorded in 2021 and a 4.7% decline from the numbers reported in 2020 with a total of 975 projects. It is worth noting that the UK reached its highest-ever project count in 2017, with 1,205 projects. Furthermore, the UK's share of all European FDI projects in 2022 was 15.6%, marking a decrease from 16.9% in 2021 and a peak of 21% in 2015. However, Figure 5.8 shows the historical trend of total values of inward and outward FDI from 2005 to 2022, showing that the total values of inward FDI in 2022 increased significantly compared to 2021. Such contradiction might result from a growing number of companies with a large scale of FDI and a decreasing number of companies with smaller scales of FDI to the UK. As is demonstrated in this figure, the total values of inward FDI in the UK have experienced a gradual decline since 2005 until 2015 and witnessed a rapid increase in 2016. After 2016, the total values of inward FDI started to decrease significantly and reached -80,432m US dollars in 2021, indicating that existing foreign investments exited the UK with a more rapid rate than FDI entering the UK.



Figure 5.8 Total value of UK's Inward and outward FDI, 2005-2022



Source: Statista, extracted from the database of values of inward and outward FDI provided by ONS, historical data of FDI total values provided by the House of Commons Library.

When we look back on Wales, as is shown in Figure 5.9, we can find that the total value of inward FDI in Wales remained relatively stable in 5 years (2012-2016) before the 2016

⁴³ https://assets.ey.com/content/dam/ey-sites/ey-com/en_uk/news/2023/6/uk-and-scotland-attractiveness-survey-2023.pdf

Referendum happened and experienced a significant increase in 2017 and 2018, potentially due to the speed-up effect encouraged by the decision of Brexit made by the Referendum. Such effect might result from business owners' perception that it might be better to have a short-term investment in Wales before 2020 when Brexit became reality instead of increasing FDI in Wales after 2020. However, such perception still requires to be examined with empirical evidence. In 2020, the total value of FDI inflow in Wales decreased by 70%, which might be possibly due to negative impacts of the pandemic on global investment flow. In 2021, Wales witnessed an increase in the total value of FDI inflow by over 600%, showing business owners and investors had an optimistic response to economic recovery in Wales in the post-pandemic era. Figure 5.9 further demonstrate that the total value of FDI inflow from EU countries to Wales experienced a significant decrease from 2016 to 2020, potentially due to EU investors' pessimistic expectations of business environments in Wales after Brexit. Conversely, the total value of FDI inflow from non-EU countries to Wales increased rapidly from 2016 to 2018. In 2021, the total value of FDI inflow from both EU and non-EU countries increased, indicating that investors from EU countries might regain confidence in the Welsh economy and business environments in Wales after witnessing the transition period of 2020. Table 5.1 shows patterns of EU and non-EU FDI projects in Wales during the same period, and it can be found that before 2017, the number of EU FDI projects was generally higher than the number of non-EU FDI projects in most years. Meanwhile, it is witnessed that both the number of EU FDI projects and the value of EU FDI in Wales experienced a huge increase in 2016, potentially due to firms' prompt response to the 2016 Referendum result, i.e., business owners being afraid of potential business uncertainty after Brexit and deciding to accelerate the FDI in the UK including Wales before the execution of Brexit deal, which is consistent with existing studies on impacts of Brexit-led uncertainty on business behaviour and perceptual response to policy shock in the UK as discussed in Section 5.1.2.

	EU projects	Non-EU projects	Total
2010	28	10	38
2011	25	12	37
2012	19	15	34
2013	21	18	39
2014	23	15	38
2015	17	25	42

Table 5.1 Number of EU and non-EU FDI projects in Wales, 2010-2021

2016	32	13	45
2017	12	40	52
2018	14	43	57
2019	24	27	51
2020	37	35	72
2021	20	23	43

Source: Foreign Direct Investment Survey from ONS and the database of FDI, experimental UK subnational estimates provided by ONS.



Figure 5.9 Total values of inward FDI in Wales, 2010-2021

Source: Foreign Direct Investment Survey from ONS and the database of FDI, experimental UK subnational estimates provided by ONS.

5.3.2.3 Economic Growth

Finally, to measure the economic growth in Wales, we use GDP per capita as the core measurement, with historical data demonstrated in Figure 5.10. As is shown in this figure, GDP per capita in Wales increased steadily by 32% in 10 years from 2010 to 2019 and decreased in 2020, potentially due to negative impacts of the pandemic on the economy. In 2021, after the pandemic-related social restrictions became the new normal and the government started to recover the economy by implementing economic stimulation policies and "with-Covid" policy, GDP per capita in Wales increased rapidly by 6.25% in one year from 2020 to 2021. As such, it seems that Brexit, especially the 2016 Referendum, did not impose any significant impact on

GDP per capita in Wales. In contrast, the Covid-19 pandemic, especially the pandemic in 2020 encouraged by the fatal original variant, might have caused significant damage to the economic growth in Wales.



Figure 5.10 GDP per capita in Wales, 2010-2021, £

Source: The author's estimates based on the database of regional gross domestic product: all ITL regions, provided by ONS. Values are nominal according to ONS database⁴⁴.

5.4 Hypotheses

Brexit as a successful attempt to leave an economic union has been widely considered as a political and economic policy shock by numerous scholars. Considering that such attempt is extremely rare in history, we find it extremely difficult to track down similar cases with as significant economic impacts as Brexit has triggered. Walker (2003) reviews economic impacts of the dissolution of the Soviet Union on today's Russia and claims that economic depression in the late 1990s in Russia resulted from extremely significant damages to the economy of Russia due to the dissolution and the shock therapy became a necessity to solve the problem. However, there are several significant differences between the UK leaving the EU and the dissolution of the Soviet Union. First, the Soviet Union was a union formed by developing countries while the EU consists of all developed countries, thus levels of economic growth between the Soviet Union and the EU are extremely different. Second, the UK left EU based on an active political operation, i.e., the 2016 Referendum, while Russia becoming independent after the dissolution was a result of passive reconstruction of political powers in the Soviet

⁴⁴ <u>https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/regionalgrossdomesticproductallnutslevelregions</u>

Union. Finally, due to relatively inactive economic exchange between Russia and other CIS members, it took Russia a much shorter period to complete economic and trade negotiations than the case of Brexit. However, Brexit still shares several similarities with previous political and economic independence events and the approach of policy uncertainty and risk perception, as discussed in previous sections, can be reasonably applied to analysis on economic impacts of Brexit.

Following discussion in Sections 5.1 and 5.2, it is noted that the existing analyses on impacts of Brexit on trade, FDI, and economic growth in Wales are still limited, especially the studies on the heterogeneity of such impacts between EU and non-EU trade partners and investments. This study seeks to fill this gap based on the contributions of the existing theories and empirical evidence in the literature. In summary, the following hypotheses are proposed for the empirical studies of this chapter:

- (1) Brexit, especially the new TCA between the UK and EU, has contributed to fluctuations in trade between Wales and its trade partners especially those in the EU, and EU and non-EU trade with Wales might have responded to Brexit differently.
- (2) Brexit has imposed a regime-switching effect on FDI in Wales and such effect might show heterogeneity between EU and non-EU FDI.
- (3) Brexit has resulted in changes in GDP per capita in Wales and might have long-term spillover effects on the Welsh economy measured by GDP per capita in the future, combined with other shocks.

5.5 Methodology

5.5.1 Trade: Synthetic Difference-in-Difference (SDID) Method

Numerous empirical studies in the fields of economics and the social sciences frequently aim to assess effects within a particular context using designs reminiscent of difference-indifference (DID). In these designs, impacts are deduced by comparing treated units to control units, allowing for time-invariant level differences between units and general common trends. However, the establishment of causal inferences hinges on the parallel trend assumption, asserting that, in the absence of treatment, treated units would have followed trajectories parallel to those of untreated units. The reasonableness of this assumption in different settings of empirical analysis requires further examination. Recently, various methodologies have emerged to relax this assumption. These include approaches where counterfactual trends are allowed to deviate from parallel, leading to partial identification (Manski and Pepper, 2018; Rambachan and Roth, 2019). Additionally, flexible procedures have been developed to effectively control for any existing differences between treated and control units (Bilinski and Hatfield, 2018), often focusing on pre-treatment periods exclusively (Bhuller et al., 2013). Furthermore, the instrumental-variable (IV) methods have been introduced that explicitly consider dynamics in pre-treatment periods (Freyaldenhoven et al., 2019).

To further meet the requirement of parallel trends in the DID setting, Arkhangelsky et al. (2021) introduce the Synthetic Difference-in-Differences estimator (SDID), amalgamating the strengths of both DID and SC methods. Similar to DID models, SDID permits treated and control units to exhibit entirely different trends before a focal reform. Simultaneously, akin to SC methods, SDID aims to judiciously generate a matched control unit, significantly reducing the reliance on parallel trend assumptions. Consequently, SDID sidesteps common pitfalls found in standard DID and SC methods, such as the inability to estimate causal relationships when parallel trends are not met in aggregate data for DID and the requirement for the treated unit to be within a "convex hull" of control units for SC. Arkhangelsky et al. (2021) put forth estimation and inference procedures, formally demonstrating the consistency and asymptotic normality of the proposed estimator. Additionally, the authors briefly address several practical considerations, including how their estimator can incorporate covariates and how it can be applied to both multiple treatment units and even multiple treatment units adopting treatment at different time periods.

Applying the SDID method to the analysis on impacts of Brexit on trade between Wales and its counterparts, we derive the causal inference of the 2016 Referendum and the end of Brexit transition period on Welsh trade. In addition, it is important to note that SDID has demonstrated consistency, asymptotic normality, and greater efficiency compared to widely used methods like Synthetic Control and Difference-In-Difference. Consequently, the potential for causal analysis using SDID appears promising, enabling the disentanglement of the specific effects of Brexit—namely, the conclusion of the transition period—from the influence of other factors, such as COVID-19, disruptions in global value chains due to the Ukrainian War, and waves of global inflation since 2022.

Briefly, the SDID methodology generates a replicated Wales, also referred to as a doppelganger Wales, that mimics the export and import behaviour and major macroeconomic performance of Wales but remains unaffected by the altered trade relationships with the EU. After reviewing all relevant data, we selected two Regions of France, i.e., Brittany and Normandy, and one

State of Germany, i.e., Schleswig-Holstein, all of which have similar patterns of imports and exports along with similar industrial structures, natural conditions, and economic growth in the sample period. Subsequently, it approximates the synthetic Welsh trade activities since January 2021 and contrasts these projections with the real Welsh export and import data. This approach facilitates the computation of the percentage shift in Welsh exports and imports compared to the hypothetical situation of Wales, as part of the UK, remaining in the EU single market. In addition, standard statistical inference tests are employed to examine the statistical significance of the observed effects. The method of SDID makes it possible to construct parallel trends between Wales and a doppelganger Wales which is a mix of states and regions in Germany and France, and then to support our DID analysis on impacts of Brexit on Welsh trade by comparing the reality and the "No-Brexit" assumption for Wales.

Technically, the interactive fixed-effects model is adopted (Xu, 2017; Athey et al., 2021) to build the following latent factor model, as is shown in Equation (9):

$$T_{it} = \gamma_i \nu_t^{\mathrm{T}} + \tau_1 \times Brexit_{it} + \tau_2 \times TCA_{it} + \epsilon_{it}$$
(9)

where *i* means each country that has trade relationship with Wales and the doppelganger Wales. The dependent variable T_{it} represents the log linearized variable of either import or export. γ_i is a $1 \times K$ vector of latent unit factors that control for time-invariant variables and v_t is a $1 \times K$ vector of latent time factors that control for all time-variant variables. *Brexit_{it}* is the Brexit dummy variable which equals to 1 after 2016 Q2 and equals to 0 before this point. *TCA_{it}* is the "actual Brexit" indicator which equals to 1 after 2021Q1 when the TCA replaced the previous UK-EU trade agreement and equals to 0 before this point. τ_1 and τ_2 measure the causal effects of the 2016 Referendum and the TCA on trade, respectively. Despite appearing rigid in its structure, this equation remains adequately flexible and can encompass a standard two-way fixed effect model as one of its potential specifications.

With regard to the technics of SDID approach for this study, we observe trade for the sample period T for a balanced panel of N units of trade volume. The initial units N_I are not exposed to the treatments of the 2016 Referendum and TCA, and the remaining units of $N_R = N - N_I$ are subject to these two treatments after 2016Q2 and the units of $N_B = N - N_I - N_R$. The SDID estimator forms the synthetic control, a doppelganger, by drawing from a pool of nevertreated units and assigning weights $\hat{\omega}_i^{sdid}$ based on the actual outcomes of the treated group before 2016Q2. Additionally, it employs time weights $\hat{\lambda}_t^{sdid}$ to achieve balance between the pre-treatment and post-treatment time periods. These time weights play a crucial role in mitigating bias when comparing post-treatment periods with significantly different pretreatment periods across the entire control unit sample. Subsequently, the time- and pairspecific weights are applied to the standard difference-in-difference estimator in a two-way panel as follows:

$$\left(\hat{\tau}^{sdid},\hat{\mu}_{1},\hat{\alpha}_{1},\hat{\beta}_{1}\right) = \arg\min_{\tau,\mu,\alpha,\beta} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} (T_{it} - \mu - \alpha_{i} - \beta_{t} - \tau_{1} \times Brexit_{it} - \tau_{2} \times TCA_{it})^{2} \widehat{\omega}_{i}^{sdid} \widehat{\lambda}_{t}^{sdid}\right) (10)$$

where $\hat{\tau}^{sdid}$ measures causal effects of exposure to treatments in the SDID setting, μ denotes the average of trade between Wales (and constructed Wales) and EU and non-EU countries, α_i represents the coefficients of time-invariant control variables, β_t represents the coefficients of time-variant control variables.

SDID employs weights to highlight units and time periods that closely resemble the treated units during the post-treatment period. The weights assigned to the synthetic control are carefully chosen to align with the pre-treatment trend of the treated units. Furthermore, a penalty is applied to discourage excessive use of units for comparison. We further use variables T_R and T_B to represent the trade condition at two turning points, i.e., the 2016 Referendum and the actual effectiveness of Brexit, respectively. The estimation of unit weights involves solving the optimization problem outlined below:

$$\left(\widehat{\omega}_{0},\widehat{\omega}_{i}^{sdid}\right) = \arg\min_{\omega_{0}\in\mathbb{R},\omega\in\Omega}\iota_{unit}(\omega_{0},\omega)$$
(11)

where for the case of analysing impacts of the 2016 Referendum on trade:

$$\iota_{unit}(\omega_0,\omega) = \sum_{t=1}^{T_R} \left(\omega_0 + \sum_{i=1}^{N_I} \omega_i T_{it} - \frac{1}{N_R} \sum_{i=N_{I+1}}^{N} T_{it} \right)^2 + \xi^2 T_R ||\omega||_2^2$$
(12)

and similarly for the case of analysing impacts of the TCA on trade:

$$\iota_{unit}(\omega_0,\omega) = \sum_{t=1}^{T_B} \left(\omega_0 + \sum_{i=1}^{N_I} \omega_i T_{it} - \frac{1}{N_B} \sum_{i=N_{I+1}}^{N} T_{it} \right)^2 + \xi^2 T_B ||\omega||_2^2$$
(13)

where:

$$\Omega = \left\{ \omega \in \mathbb{R}^{N}_{+}, : \sum_{i=1}^{N_{I}} \omega_{i} = 1, \omega_{i} = \frac{1}{N_{R} + N_{B}} \text{ for all } i = N_{I+1}, \dots, N \right\}$$
(14)

In equations above, $\iota_{unit}(\omega_0, \omega)$ represents the equation that measures potential gaps in trade between the control and treatment groups and is used to derive the estimation of unit weights. It is important to note that the measurement of causal effects of the 2016 Referendum and the actual effectiveness of Brexit on trade is repeated twice, as is shown in Equations (12) and (13), which is consistent with the requirement of demonstrating trade's impulse response to these two events by comparing such response between the reality of trade in Wales and trade in the constructed Wales. The derivation and calculation of the regularisation parameter ξ is given by the SDID setting designed by Arkhangelsky et al. (2021). \mathbb{R}^{N}_{+} denotes the range of all feasible data of trade utilised in this study. Finally, the SDID setting is complete, and we will proceed to empirical results in Section 5.5 by using Stata to analyse the sample data mainly based on Equation (11).

It is also important to notice that SDID analysis focuses on impacts of Brexit on international trade between Wales and foreign countries based on the aggregate values of export and import, thus it uses macro-level data, i.e., trade volumes every year, instead of firm-level data. As a result, the structure of international trade might not be the centre of this analysis. Macro-level data, such as national or regional trade volumes over time, is well-suited for SDID, provided that: (1) there is a clear intervention (treatment) such as Brexit, trade agreements, tariff changes. (2) there are suitable control units (similar patterns of other variables, i.e., parallel trend). All of these requirements are met in this analysis due to (1) Brexit is a clear policy intervention; (2) Extremely similar economic and business patterns are found between Wales and regions of the control group. In terms of potential dominance of large MNCs in trade, the author has found that international trade in regions of the control group also highly depends on MNCs^{45,46,47}, which is an interesting finding, and it is a future plan to focus on how firms respond to Brexit individually and whether MNCs have dominated such response due to their vulnerability as long as firm-level panel data is available.

5.5.2 FDI: Structural Vector Autoregression (SVAR) Markov-Switching Model

The Structural Vector Autoregression (SVAR) model makes up for the shortcomings of the VAR model in economic foundations by relaxing the setting that the current impact of variables

⁴⁵ https://www.bretagne.cci.fr/actualite/chiffres-cles-du-commerce-et-services-de-proximite-enbretagne/bretagne

 ⁴⁶ <u>https://lekiosque.finances.gouv.fr/fichiers/Etudes/Brochures/Reg_05.pdf</u>
 ⁴⁷ <u>https://www.ihk.de/schleswig-holstein/produktmarken/branchen/handel/daten-zahlen-fakten</u>

must be zero and comprehensively considering the impact of the lagged data of the independent variables and other variables' current and lagged data in the process of regression (Gottschalk, 2001). It has also been widely applied to numerous studies that focus on economic and financial shocks on certain economic variables. For instance, Hu et al. (2018) use the SVAR model to analyse impacts of oil price shock on stock markets in China and find that demand-side shocks of oil price have a significant impact on Chinese stock markets in both short and long run. Neaime et al. (2018) examine main causes of the 2010 Eurozone debt crisis by applying the SVAR method and find the causal effects of imbalances in the balance-of-payment and lack of nominal adjustment measures in Greece that led to the crisis. Ghassan et al. (2013) use the asymmetric SVAR model to measure impacts of the 2008-2009 Financial Crisis on economic growth in Saudi Arabia and reveal that the crisis shock resulted in significant decline in exports and GDP growth.

More recently, the application of SVAR model is often combined with the Markov-Switching method which meets the requirements of large panel data and regime-switching realities. Cuestas & Tang (2021) use the Markov-Switching SVAR model to examine impacts of changes in exchange rates on stock returns in China and find that exchange rate shocks tend to have significant impacts on stock returns while the long-term changes in exchange rates will not lead to Granger-cause on stock returns. Esmaeili & Rafei (2021) adopt the SVAR model with the Markov-Switching framework to analyse scrutinise the impact of structural shocks of GDP, oil revenues, and inflation on Iran's electricity consumption and find that only inflation shocks have a significant impact on electricity consumption. Regarding impacts of Brexit as an economic shock on FDI inflow in the UK, several studies have justified causal effects of Brexit on decline in FDI inflow from certain groups of countries to the UK by using the neoclassical growth model (McGrattan & Waddle, 2020), the gravity model of FDI attractiveness (Dhingra et al., 2016), and the general-equilibrium numerical simulation model (Latorre et al., 2020). To the best of our knowledge, there are no existing studies that apply the SVAR method to analysing this issue.

Theoretically, for the study on impacts of Brexit on FDI inflow in Wales, following the method of decomposing determinants of FDI designed by Bilgili et al. (2012), the probability of switches in volatility from low level (contraction of FDI) to high level (expansion of FDI) is captured as depicted by the Markov Regime-Switching method as shown in Equation (15):

$$p(y_t|Y_{t-1}, X_{t,s_t} = \begin{cases} f\{y_t|Y_{t-1}, X_t; \theta_1\}, & s_t = 1\\ f\{y_t|Y_{t-1}, X_t; \theta_M\}, & s_t = M \end{cases}$$
(15)

where $Y_{t-1}\{y_{t-j}\}_{j}^{\infty} = 0$ indicates the history of the dependent time-series variable y_t that depends on unobservable state variable $s_t \in \{1, 2, ..., M\}$ representing the probability of being in a particular state of the data. X_t and θ_M denote exogenous variables and parameter vector, respectively (Krolzig, 2000). Thus, Equation (16) governs the transition between the states (regimes) in a first-order Markov Regime-Switching process:

$$\begin{cases}
P\{s_t = 1 | s_{t-1} = 1\} = p \\
P\{s_t = 0 | s_{t-1} = 1\} = 1 - p \\
P\{s_t = 0 | s_{t-1} = 0\} = q \\
P\{s_t = 1 | s_{t-1} = 0\} = 1 - q
\end{cases}$$
(16)

where $s_t = 0$ or $s_t = 1$ represents the unobserved state of the equation. The transition probability adopts the range $0 \le p_{ij} \le 1$ and the sum of transition probabilities is one. Then, we use Δy_t and μ to represent the growth rate of y_t and the mean value of y_t , respectively. The general form of Markov Regime-Switching model is given by Equation (17):

$$\Delta y_t - \mu(s_t) = A_1 \left(\Delta y_{t-1} - \mu(s_{t-1}) \right) + \dots + A_p \left(\Delta y_{t-p} - \mu(s_{t-p}) \right) + u_t \tag{17}$$

where the error term, u_t , is normally and independently distributed. The low-level ($s_t = 0$, before Brexit) and the high-level ($s_t = 1$, after Brexit) regimes are correlated with different conditional distributions of Δy_t and μ that depend on regimes. Following Liu and Mumtaz (2010), we establish the multivariate Markov Regime-Switching baseline model to examine impacts of Brexit on FDI inflow in Wales:

$$FDI_{it} = B_0(s_t) + \sum_{i=1}^{n} B_i X_{it}(s_t) + u_t$$
(18)

where FDI_{it} represents the total value of FDI inflow from country *i* to Wales at time *t*, B_i denotes the time-varying parameters after calibration based on historical data, and X_{it} includes all explanatory variables that control for the economic growth in country *i* at time *t*. After applying the SVAR method, Equation (18) can be rewritten to the following format:

$$M_{it} = \sum_{j=1}^{p} A(s_t) M_{i,t-j} + B(s_t) u_t$$
(19)

where

$$M_{it} = \begin{pmatrix} FDI_{it} \\ y_{it} \\ \pi_{it} \\ r_{it} \\ E_{it} \end{pmatrix} \cdot u = \begin{pmatrix} u_1, S_t \\ u_2, S_t \\ u_3, S_t \\ u_4, S_t \\ u_5, S_t \end{pmatrix}$$

and *FDI*, *y*, π , *r*, and *E* mean FDI inflow from each country, GDP per capita, inflation rate in the FDI country of birth, exchange rate of own currency against US dollars, and the dummy showing whether the FDI country of birth is an EU member. Based on this setting, addressing the issue of identification refers to identifying the impulse-response matrix $B(s_t)$, which can be used to extract the contemporaneous interactions between the elements of M_{it} . Identification of $B(s_t)$ requires n^2 restrictions within each regime, and we adopt the scheme of identification developed by Ehrmann et al. (2003) and impose the restrictions that FDI changes will respond positively to shocks in GDP growth, inflation, and exchange rate growth. With regard to the EU membership, we assume that EU member countries will have a more significant response to Brexit regarding FDI to Wales, compared to non-EU countries. As is discussed in previous sections, EU-related FDI inflow to Wales has occupied over 50% of total FDI inflow in 2000-2018 and is still an important component in Welsh economy. Thus, it is important to further examine how EU and non-EU FDI inflow to Wales responded to Brexit differently.

While market-seeking FDI may not be a major driver in Wales, GDP still reflects general economic conditions, including productivity, infrastructure investment, and overall business confidence. A growing economy signals stability and improves investment attractiveness, even for export-oriented or resource-seeking FDI. In terms of putting Wales GDP as a RHS variable for FDI, literature review given in Section 5.1.2 shows that economic growth measured by GDP can influence FDI and needs to be controlled since different levels and dynamics of GDP in various regions will impact dynamics of FDI inflow in corresponding regions. FDI analysis in this chapter focuses on impacts of Brexit on inward FDI in Wales and the author is aware that Brexit might have caused endogenous fluctuations of economic growth, measured by GDP, thus it is necessary to consider GDP as an explanatory (and also control) variable for FDI. In fact, existing studies have found that economic growth and investment in small open economies are more vulnerable to policy shocks (Cardia, 1991; Mendoza, 1991), thus it is important to include GDP in analysis on impacts of Brexit on inward FDI in Wales.

5.5.3 Economic Growth: SCM approach & NiGEM model

The SCM, i.e., the Synthetic Control Method, devised as a case-study method, enhances the selection of the control group for comparison with the treatment unit. Through a weighting process, it constructs a counterfactual scenario distinct from the observed case of treated units. This counterfactual is more suitable for comparison with the treated unit than a manually selected control group, as the SCM ensures greater similarity between the control and treated groups during the pre-treatment period. This stands in contrast to methods like the difference indifference (DiD) approach. The details of the SCM are extensively explained by Abadie et al. (2010) who investigate the impact of a tobacco control program on smoking incidence.

The SCM shares a fundamental concept with the DiD approach. In both methods, the comparison involves tracking the progress of the treated unit alongside a counterfactual. The key distinction lies in the intuitive approach: while the DiD approach typically involves manually selecting control units and potentially adjusting for variations in their characteristics compared to the treated unit, SCM takes a different route. Instead of manual selection, SCM constructs a counterfactual by assigning weights to the characteristics of the control group. This weighting aims to create a counterfactual unit with a pre-intervention trajectory similar to that of the treated unit. The SCM for our analysis on impacts of Brexit on GDP per capita in Wales closely aligns with the exposition of SCM in the paper by Abadie et al. (2010) and adopts similar procedures of model construction. The general procedures are as follows.

Assume there are J + 1 units of selected samples with j = 1 being the treated unit, while units from j = 2 to j = J + 1 are control units utilised to construct a counterfactual for j = 1. The impacts of Brexit on GDP per capita in Wales, denoted by α , represent the difference between changes in the dependent variable of the treated unit Y_{1t} and the control group Y_{jt}^N where j = 2, ..., J + 1. D_{ij} denotes the dummy variable taking the value of 1 if the sample unit is a treated unit and the recorded period is a post-intervention one, i.e., the sample country has experienced Brexit in the post-Brexit period. To further examine impacts of the 2016 Referendum and the effectiveness of Brexit starting in January 2021, the dummy is analysed twice in accordance with two key turning points, i.e., 2016Q2 and 2021Q1. Thus, we have two baseline equations shown below:

$$Y_{jt} = Y_{jt}^N + \alpha_{jt} D_{jt} \tag{20}$$

$$\alpha_{it} = Y_{jt}^I - Y_{jt}^N \tag{21}$$

where

$$D_{jt} = \begin{cases} 1 \ if \ j = 1 \ and \ t > T_0 \\ 0, otherwise \end{cases}$$

The counterfactual dependent variable is determined using a group of determinants in a factor model, some of which are covariates Z_j , and others being unobserved effects u_j and a vector of transitory shocks ε_{jt} . The variables in the equation of Y_{jt}^N are weighed such that differences between the pre-intervention evolution of the treated unit and its counterfactual is minimised. The weights (*W*) of treated and control units are positive, and the sum of weights is strictly 1. As such, Equations (20) and (21) can be further converted into the following formats:

$$\alpha_{1t} = Y_{1t}^I - Y_{1t}^N = Y_{1t} - Y_{1t}^N \tag{22}$$

$$Y_{1t}^N = \delta_t + \theta_t Z_j + \lambda_t u_j + \varepsilon_{jt}$$
(23)

$$W = w_2, \dots, w_{l+1}$$
 (24)

where

$$w_J \ge 0$$
, $J = 2, ..., j + 1$, and $w_2 + \dots + w_{J+1} = 1$

For each synthetic control, values of the dependent variable can be calculated by:

$$\sum_{j=2}^{J+1} w_j Y_{jt} = \delta_t + \theta_t \sum_{j=2}^{J+1} w_j Z_j + \lambda_t \sum_{j=2}^{J+1} w_j u_j + \sum_{j=2}^{J+1} w_j \varepsilon_{jt}$$
(25)

where

$$\sum_{j=2}^{J+1} w_j Y_{j1} = Y_{11}, \qquad \sum_{j=2}^{J+1} w_j Y_{jT_0} = Y_{1T_0}, \qquad \sum_{j=2}^{J+1} w_j Z_j = Z_1$$

Following Abadie et al. (2010), it can be shown that if the number of pre-intervention periods is large relative to the scale of transitory shocks, then:

$$Y_{1t}^N - \sum_{j=2}^{J+1} w_j Y_{jt} \cong 0$$
 (26)

It is important to note that the SCM approach also creates a duplicate Wales, or the "doppelganger Wales", by using the data of two Regions of France, i.e., Brittany and Normandy, and one State of Germany, i.e., Schleswig-Holstein, all of which have similar patterns of imports and exports along with similar industrial structures, natural conditions, and economic

growth in the sample period. The weights to construct doppelganger of this SDID analysis are 0.56 for Brittany, 0.28 for Normandy, and 0.16 for Schleswig-Holstein after calibration. The treated group in this section denotes the data of Wales where Brexit, i.e., the designated treatment, was imposed, while the control group includes the data of three regions above where Brexit was not imposed in these regions. By estimating changes in GDP per capita between the real data in Wales and the constructed data in the doppelganger Wales, it is possible to measure the causal effects of Brexit on GDP per capita, a significant measurement demonstrating the economic growth in Wales, during the sample period.

Finally, the NiGEM model is utilised to perform initial estimation of GDP per capita of the Welsh economy following the expected long-term impacts of Brexit combined with several other shocks such as the Covid-19 pandemic and the Ukrainian War. Detailed illustration of the NiGEM model is given in Chapter 4.2.4. As a comprehensive macroeconomic model, the NiGEM can provide us with initial estimates of fluctuations in specific macroeconomic variables impacted by policy shocks by including numerous variables for the majority of countries around the world and benefit from the NiGEM database and analysis software.

5.6 Results

5.6.1 Trade

The SDID estimation is performed for two different samples, i.e., trade between Wales and EU, and between Wales and non-EU countries, and for two different flows, i.e., exports and imports, separately. Examining the dynamics of bilateral trade between Wales and EU countries with a focus on exports and imports, we can assess the impact of two significant Brexit-related events, i.e., the 2016 Referendum in 2016Q2 and the effectiveness of Brexit in 2021Q1, on the trade between Wales and the EU. Meanwhile, trade between Wales and non-EU countries has also been examined to support the analysis on impacts of Brexit on non-EU trade of Wales. As is discussed in previous sections, trade between the UK and non-EU trade partners might have been impacted by Brexit due to changes in expectations of business environment in the UK and renegotiation of trade agreements between UK and non-EU countries. Wales, as a significant part of the UK economy, shares a considerable proportion of trade with non-EU countries, especially with the US and China. Another reason for considering non-EU trade is potential disruptions in the value chain due to Brexit, where trade between Wales and non-EU countries might rely on suppliers from the EU. As such, it is believed that analysis on impacts of Brexit on non-EU trade of Wales is essential. Finally, to eliminate external impacts of the fluctuation

in the gold price and the surge in energy prices due to the Ukrainian War, trade data of mineral fuels (HS27) and gold (HS7108) is removed to provide a more feasible estimate.

Following instructions above, Figures 5.11-5.14 are obtained, demonstrating the results of SDID estimates and actual log linearised quarterly trade data between Wales and EU and non-EU trade partners, where the actual log linearised quarterly trade data is in green and the SDID estimates for the doppelganger Wales are shown in red. Two bold vertical lines represent two key turning points, i.e., the 2016 Referendum in 2016Q2 and the effectiveness of Brexit (the end of transition period) in 2021Q1. The average difference between the green and red lines following these two turning points is interpreted as the causal effect of two major Brexit-related events, showing the potential impacts of Brexit on trade between Wales and its counterparts by comparing the actual trade data of Wales and the constructed trade data of the Doppelganger Wales based on the SDID analysis. Figure 5.11 shows that the trade volume of Wales exports to the EU is significantly lower than that of Doppelganger Wales exports to the EU from 2016Q2 to 2021Q2, indicating that the 2016 Referendum seems to have significantly negative impacts on Wales exports to the EU. However, the difference between the green and red lines increased from 2021Q1 to 2021Q2 for a short period with an impulse response, showing that the actual effectiveness of Brexit seems to have no persistent impacts on Wales exports to the EU. This finding is consistent with relevant studies such as Du et al. (2023) who claim that additional requirements and restrictions on the UK-EU trade due to Brexit, such as extra registrations and port regulations, contributed to relatively lower UK exports to the EU compared to the non-Brexit conditions.

Figure 5.11 Wales Export to the EU: SDID Results



Source: Author's estimation based on the SDID method. Log scale for quarterly data of import/export in pound sterling. Gold (HS7108) and mineral fuels (HS27) are excluded.

Figure 5.12 shows that both the 2016 Referendum and the effectiveness of Brexit in 2021Q1 seem to have no significant impacts on imports from the EU to Wales. However, the difference between imports from the EU to real Wales and to the Doppelganger Wales is significant from 2018Q3 to 2021Q3, potentially due to the relatively stronger economic growth in the sample regions used to create the Doppelganger Wales. It is also important to note that the GDP growth rates in the sample regions in Germany and France were significantly higher than that in Wales from 2018 to 2021⁴⁸.

Figure 5.12 Wales Import from the EU: SDID Results

⁴⁸ See World Bank Open Database: <u>https://databank.worldbank.org/</u>



Source: Author's estimation based on the SDID method. Log scale for quarterly data of import/export in pound sterling. Gold (HS7108) and mineral fuels (HS27) are excluded.

Figure 5.13 reveals that imports from non-EU countries to Wales were significantly more than the constructed condition from 2016Q2 to 2020Q1, showing that the 2016 Referendum might encourage firms and households in the UK to turn to products from non-EU countries given the uncertainty of the UK-EU trade after Brexit. The period from 2020Q1 to 2021Q1 witnessed the decline in imports from non-EU countries to both real Wales and the Doppelganger Wales, which is likely to result from the Covid-19 pandemic and its interruptions to the supply chain. After 2021Q1, the expected non-EU imports to Wales in the Doppelganger Wales were more than real Wales, which particularly echoes Dhingra et al. (2016) who claim that the long-term negative impacts of Brexit on trade between UK and non-EU countries might persist.

Figure 5.13 Wales Import from Non-EU: SDID Results



Source: Author's estimation based on the SDID method. Log scale for quarterly data of import/export in pound sterling. Gold (HS7108) and mineral fuels (HS27) are excluded.

Figure 5.14 demonstrates trends that are similar to Wales exports to the EU, especially during the period of 2017Q2-2020Q1, indicating that, after the 2016 Referendum, concerns over Brexit-related additional restrictions on UK exports might also widely exist in firms that export products to non-EU countries. However, the difference between the green and red lines started to be narrowed after 2020Q1, potentially due to the uncertainty of the trade conditions between the UK and non-EU counterparts being eliminated given that more detailed information of Brexit became available. Exports to non-EU countries from both real Wales and Doppelganger Wales experienced significant decline in 2020Q1, which is consistent with Du & Shepotylo (2022) who claim that UK exports to non-EU countries such as the US and China witnessed a rapid decrease due to the disruption of global supply chains amid lockdown policies in multiple countries.

Figure 5.14 Wales Export to Non-EU: SDID Results



Source: Author's estimation based on the SDID method. Log scale for quarterly data of import/export in pound sterling. Gold (HS7108) and mineral fuels (HS27) are excluded.

Table 5.2 presents the results of regression analysis based on the SDID approach showing the causal effects of Brexit on trade between Wales and its counterparts. It is particularly important to note that the outcome of aggregate trade flows, involving only a single treated unit, lacks the precision needed for accurate estimates of the effect, which is due to its reliance on the placebo method that is inefficient and possesses unclear statistical properties. Leveraging bilateral data, we can take advantage of a larger number of treated units, enabling us to estimate the coefficient more accurately. This approach allows for a more feasible analysis of the impacts of Brexit on trade of Wales. Columns (1)-(4) represent the conditions for bilateral imports from EU, bilateral imports from non-EU, bilateral exports to EU, and bilateral exports to non-EU, respectively. We insert two dummy variables, i.e., Referendum and Effectiveness, into the benchmark SDID model to indicate two major Brexit-related events while the value of both dummies equals to 1 if the regime changes and 0 for the initial condition. As is shown in the table, the 2016 Referendum has significant impacts on bilateral imports from non-EU, exports to the EU and non-EU, i.e., it significantly encourages imports from non-EU trade partners to Wales and discourages exports to both EU and non-EU countries from Wales, which is consistent with the comparison results shown in Figures 5.11-5.14. Meanwhile, the actual effectiveness of Brexit seems to have no significant impacts on trade between Wales and its counterparts. We have also noticed that several reasons proposed by existing studies, such as the clarification of details

of Brexit-related trade policies (Kren & Lawless, 2024) and the stabilisation of trade flows between the UK and the rest of the world (Ahmad et al., 2023) might explain our finding that impacts of Brexit on trade between Wales and its counterparts seem to become insignificant since 2020.

Variable: Import/Export	(1)	(2)	(3)	(4)
Referendum	-0.047	0.043**	-0.053***	-0.048**
	(0.204)	(0.992)	(0.332)	(0.015)
Effectiveness	0.004	-0.005	0.002	0.006
	(0.032)	(0.054)	(0.112)	(0.027)
Macro FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	4,205	3,091	4,205	3,091
R^2	0.772	0.805	0.835	0.821

Table 5.2 Regression results of SDID analysis on impacts of Brexit on trade of Wales

Notes: The table represents results from SDID analysis estimated by fixed effects method. Standard errors are reported in parentheses. */**/*** indicates the difference in means between Wales and Doppelganger Wales is statistically significant at the 0.1/0.05/0.01 level.

5.6.2 FDI Inflow

Table 5.3 shows the results of Markov Regime-Switching analysis on impacts of Brexit on FDI inflow to Wales during the sample period, i.e., 2011-2022, with quarterly data of FDI inflow. The second column of Table 5.3 shows coefficients of the constant and potential explanatory variables with regard to FDI inflow in the basic Markov Regime-Switching (MSM1) setting. The third and fourth columns of Table 5.3 reveal estimation results of MSM2 and MSM3, respectively. The MSM2 setting considers fluctuations in energy prices and the MSM3 setting further examines impacts of import and export growth in Wales on FDI inflow before and after two major Brexit-related events during the sample period. Three regimes represent three conditions that are divided by two events, i.e., the 2016 Referendum (2016Q2) and the actual effectiveness of Brexit (2021Q1). As such, Regime 0 represents the period from 2011Q1 to 2016Q2; Regime 1 represents the period from 2016Q3 to 2020Q4; and Regime 2 represents the period from 2021Q1 to 2022Q4. In the table below, "GDP Growth-ROW" represents the average GDP growth rate for all countries that have FDI inflow in Wales. The "Country Risk-

UK" denotes the Country Risk Index published by OECD annually⁴⁹, which comprehensively provides the analysis of political and economic risks that each OECD country faces. The "Energy Price" denotes the quarterly average level of WTI crude oil prices. It is increasingly important to focus on external impacts of rising energy prices on international investment due to the Ukrainian War and other geopolitical conflicts.

	MSM1	MSM2	MSM3
Constant	-1.203***	-1.032***	-0.992***
(Regime 0)	(0.001)	(0.000)	(0.000)
Constant	-1.105***	-1.045***	-1.002***
(Regime 1)	(0.000)	(0.001)	(0.000)
Constant	-0.882***	-0.994***	-0.927**
(Regime 2)	(0.008)	(0.002)	(0.021)
GDP Growth-Wales	0.285***	0.274***	0.203***
(Regime 0)	(0.005)	(0.003)	(0.002)
GDP Growth-Wales	0.284**	0.265***	0.198**
(Regime 1)	(0.023)	(0.007)	(0.032)
GDP Growth-Wales	0.214**	0.201*	0.196*
(Regime 2)	(0.021)	(0.056)	(0.072)
GDP Growth-ROW	-0.002	-0.005	-0.006
(Regime 0)	(0.291)	(0.101)	(0.544)
GDP Growth-ROW	-0.005	-0.004	-0.005*
(Regime 1)	(0.144)	(0.128)	(0.089)
GDP Growth-ROW	-0.006	-0.012	-0.008
(Regime 2)	(0.199)	(0.438)	(0.111)
Exchange Rate-GBP/USD	-0.003	-0.005*	-0.004**
(Regime 0)	(0.125)	(0.097)	(0.047)
Exchange Rate-GBP/USD	-0.006*	-0.007**	-0.007**
(Regime 1)	(0.077)	(0.021)	(0.011)
Exchange Rate-GBP/USD	-0.012***	-0.011***	-0.009***
(Regime 2)	(0.002)	(0.005)	(0.007)

Table 5.3 SVAR Markov Regime-Switching Analysis for FDI inflow in Wales: 2011-2022

⁴⁹ <u>https://www.oecd.org/trade/topics/export-credits/arrangement-and-sector-understandings/financing-terms-and-conditions/country-risk-classification/</u>

Inflation Rate-UK	-0.006*	-0.005	-0.008**
(Regime 0)	(0.079)	(0.292)	(0.028)
Inflation Rate-UK	-0.003**	-0.005**	-0.006**
(Regime 1)	(0.032)	(0.021)	(0.022)
Inflation Rate-UK	-0.005**	-0.004**	-0.005***
(Regime 2)	(0.012)	(0.018)	(0.009)
Inflation Rate-ROW	-0.006	-0.003	-0.008
(Regime 0)	(0.119)	(0.327)	(0.402)
Inflation Rate-ROW	-0.004	-0.003	-0.005
(Regime 1)	(0.109)	(0.217)	(0.287)
Inflation Rate-ROW	-0.007	-0.006	-0.003
(Regime 2)	(0.283)	(0.788)	(0.196)
Country Risk-UK	-0.892	-0.735	-0.722
(Regime 0)	(0.822)	(0.731)	(0.691)
Country Risk-UK	-0.372***	-0.389***	-0.324***
(Regime 1)	(0.001)	(0.001)	(0.000)
Country Risk-UK	-0.204***	-0.203***	-0.199***
(Regime 2)	(0.001)	(0.000)	(0.000)
Energy Price		-0.008	-0.005
(Regime 0)		(0.299)	(0.204)
Energy Price		-0.005***	-0.003***
(Regime 1)		(0.001)	(0.000)
Energy Price		-0.012***	-0.004***
(Regime 2)		(0.000)	(0.000)
Import Growth			-0.021
(Regime 0)			(0.398)
Import Growth			-0.017
(Regime 1)			(0.233)
Import Growth			-0.015
(Regime 2)			(0.125)
Export Growth			0.018
(Regime 0)			(0.492)
Export Growth			0.008

(Regime 1)	(0.231)
Export Growth	0.007
(Regime 2)	(0.449)

Notes: P values are reported in parentheses. */**/*** indicates the coefficient is statistically significant at the 0.1/0.05/0.01 level.

As is shown in the table above, MSM1 employs impacts of potential explanatory variables on FDI inflow in Wales throughout three different regimes, i.e., the status quo, after the 2016 Referendum, and after the effectiveness of Brexit followed by the end of the transition period. The statistical significance of each coefficient is clearly demonstrated. Results of MSM1 show that for Regime 0 (status quo before 2016Q2), the constant, GDP growth rate in Wales, and inflation rate in the UK are found significant in determining FDI inflow in Wales; for Regime 1 (2016Q3-2020Q4), the constant, GDP growth rate in Wales, exchange rate of GBP-USD, inflation rate in the UK, and the country risk index have significant correlation with FDI inflow in Wales; for Regime 2 (2021Q1-2022Q4), the constant, GDP growth rate in Wales, exchange rate of GBP-USD, inflation rate in the UK, and the country risk index have significant correlation with FDI inflow in Wales; for Regime 2 (2021Q1-2022Q4), the constant, GDP growth rate in Wales, exchange rate of GBP-USD, inflation rate in the UK, and the country risk index are found significant in determining FDI inflow in Wales. MSM1 concludes that Brexit-related events has impacts on FDI inflow in Wales through mechanisms of rising country risk index and concerns over fluctuations in GBP exchange rates, i.e., the value of pound sterling under the background of Brexit.

Similarly, MSM2 and MSM3 demonstrate similar patterns while MSM2 further highlights the significance of energy price in the correlation between Brexit-related events and FDI inflow in Wales and MSM3 shows that the trade between Wales and its counterparts seems not to have significant impacts in this correlation. As we can see in the third column, coefficients of energy price in Regimes 1 and 2 become statistically significant while that in Regime 0 is insignificant. Following Grégoire et al. (2020), we believe that the growing significance of energy prices in the correlation between Brexit and FDI inflow in Wales is not necessarily related to Brexit-related motions and actual effectiveness since fluctuations in energy prices have been a universal issue for the majority of countries in the world due to disruptions on supply chain of energy after the Covid-19 outbreak and the Ukrainian War. MSM3, denoted in the fourth column, shows that coefficients of both import and export of Wales are not statistically significant for all regimes, indicating that fluctuations in trade between Wales and its counterparts seem not to have become a significant mechanism through which Brexit impacted FDI inflow in Wales. We suppose that it might be due to the fact that the trade between Wales and its counterparts has not been significantly impacted by Brexit-related events, according to

historical data that we have interpreted in previous sections. In conclusion, it is feasible to note that GDP growth rate in Wales, exchange rate of GBP-USD, inflation rate in the UK, and the country risk index of the UK are potentially explanatory variables that trigger impulse response due to Brexit-related events.

Additionally, it is important to recognize that, despite the initial inclination to eliminate seemingly insignificant variables to potentially enhance the accuracy of impulse-response estimates, two crucial considerations should be kept in mind. Firstly, even though the outcomes are not explicitly presented, the excluded variables played a vital role in reasonably identifying the regimes, aligning with the overall understanding of the UK macroeconomic state during the analysed sample period. This outcome is expected, given that the unique aspects of the retained series carry more significance in smaller-scale systems than when all variables are included. Secondly, while uncertainty may persist in the variables comprising the smaller-scale system, the system itself may not accurately reflect the macroeconomic state, which is pivotal for our analysis, as previously emphasized. As this study intentionally adopts a setup mirroring the prevalent SVAR, solving a Neo-Keynesian DSGE model of a macroeconomy augmented with an inward FDI variable, smaller-scale econometric models are not deemed suitable for these reasons.



Figure 5.15 Impulse-Response Graphs based on SVAR-MSM

Notes: Graphs above show responses of the percentage change of the inward FDI to a shock of each variable based on the regime of status quo. The graphs also depict the 20% and 90% confidence intervals, following Uhlig (2005) obtained by the bootstrap.

Figure 5.15 depicts the results of impulse-response analysis on potential explanatory variables that lead to fluctuations in FDI inflow to Wales under the background of Brexit-related events. It shows that a positive shock in GDP growth in Wales can result in an immediate positive response with regard to FDI inflow to Wales, and such positive impacts will last for 12 periods. Meanwhile, positive shocks in exchange rate of GBP-USD, inflation in the UK, and the country risk index of the UK can significantly cause FDI inflow to Wales to decrease and such decline can last for a long period. These findings are consistent with the existing studies, such as Hansen & Rand (2006) who claim that inward FDI is positively correlated with GDP growth and rising inflation rates can discourage inward FDI, and Hayakawa et al. (2013) who reveal that growing political and economic risks in a country can significantly lead to declining FDI inflow to this country. An et al. (2023) further highlight the negative impacts of Brexit-related uncertainty on investment in the UK due to growing concerns over risks of investment. When we insert the narrative of impacts of Brexit on FDI inflow to Wales into the impulse-response analysis, it might be feasible to conclude that concerns over fluctuations in the value of pound sterling, inflation waves, and growing country risks of the UK after Brexit could result in the decrease in FDI inflow to Wales. Fortunately, GDP growth in Wales has shown resilience and seems not to have been significantly impacted by Brexit, thus FDI inflow to Wales might have been encouraged by the resilient Welsh economy and did not present extreme decline in the past few years.

5.6.3 Economic Growth

It is crucial to highlight that the SCM approach generates a replicated counterpart of Wales, also referred to as the "doppelganger Wales" which is constructed by combining data from two French regions, namely Brittany and Normandy, and one German state, Schleswig-Holstein, with proportions of 35%, 35%, and 30%, respectively. The distribution of proportions follows previous comparison studies on regional economic growth in the UK, France, and Germany, such as Bowen (2020) and Shutters et al. (2021) and also considers the historical data of GDP growth rates in these regions with focus on their similarities in economic growth. These regions share similar patterns of imports and exports, as well as comparable industrial structures, natural conditions, and economic growth during the specified sample period. In this context, the treated group pertains to the data from Wales, where Brexit, the designated treatment, was implemented. On the other hand, the control group comprises the data from the three aforementioned regions where Brexit was not imposed. By assessing the changes in GDP per capita between the actual data in Wales and the constructed data in the doppelganger Wales, it

becomes possible to quantify the causal effects of Brexit on GDP per capita. This measurement is significant as it serves as an indicator of economic growth in Wales throughout the sample period.

Figure 5.16 shows the gaps in GDP per capita between real Wales and the Doppelganger Wales which is constructed by combining data of GDP per capita in three designated regions in France and Germany with allocated proportions. It is important to note that the economic growth, the industrial structure and demographic patterns in these regions highly resemble those in Wales, thus as is demonstrated in Figure 5.16, the data of GDP per capita in the Doppelganger Wales extremely fits that in real Wales from 2010 to 2016. However, GDP per capita in the Doppelganger Wales starts to significantly exceed that in real Wales from 2017 to 2021, which indicates that Brexit-related concerns over economic uncertainty in the UK driven by the 2016 Referendum might have caused negative impacts on GDP per capita in Wales, compared with the constructed non-Brexit condition. Since 2021, gaps in GDP per capita between Wales and Doppelganger Wales start to narrow down, potentially due to declining concerns over the economic uncertainty brought by Brexit after the UK-EU trade agreement and other non-EU economic negotiations became clear. In 2020, all countries have witnessed the outbreak of Covid-19 pandemic and its negative impacts on local economic growth, which can be seen in this figure. In 2022, with the UK and the majority of EU countries abolishing Covid-19 lockdown policies, economic growth in the UK and EU experienced a significant increase.



Figure 5.16 Gaps in GDP per capita between Wales and Doppelganger Wales

Source: Author's estimation based on the data of GDP per capita in Wales, Brittany, Normandy in France, and Schleswig-Holstein in Germany.
It is important to further discuss potential mechanisms through which Brexit might have imposed negative impacts on GDP per capita in Wales compared with other EU economies that have extremely similar economic patterns but have not experienced Brexit. Two potential mechanisms are impacts of Brexit on inward FDI in Wales and the trade between Wales and its counterparts, especially EU countries and regions, both of which have been quantitatively examined in previous sections. Meanwhile, as is shown in these sections, we notice that negative impacts of Brexit on inward FDI in Wales and trade of Wales are more statistically significant during 2016Q3-2020Q4, i.e., from the 2016 Referendum to the end of transition period, compared to the condition after the effectiveness of Brexit from 2021Q1. Following Nasir & Morgan (2018), we suppose that the temporary shock of exchange rates of pound sterling due to the 2016 Referendum might be the major reason for the lower GDP per capital in real Wales compared to the Doppelganger Wales. GDP per capita for regions that are used to construct the Doppelganger Wales is expressed in euros and converted to pounds sterling after the author's conversion, which might result in significant gaps in GDP per capita from 2017 to 2021.

Finally, to provide an initial estimate of GDP per capita in Wales in the next five years, we take advantage of the NiGEM model and database of major macroeconomic variables in 156 countries and regions including Wales. The NiGEM database benefits from monthly updates and comprehensive political and economic information across the world, which enables us to include potential impacts of external shocks such as the pandemic and geopolitical conflicts. Following Hantzsche et al. (2018), the NiGEM model can perform feasible estimation for regional economic growth amid the era of uncertainty. Technically, the Extended Path method for solving non-linear equations is employed to resolve the model. By default, agents within the model operate under rational expectations, aligning their expectations with the model's predictions. This implies that the current expectations of agents are unaffected by the variance of future shocks. In practice, this involves recalculating expectations along the solution path until convergence is reached, as elaborated by Barrell et al. (2003). Additionally, the model can be solved in a backward-looking mode using alternative equations that lack forward-looking terms.

The NiGEM estimates of GDP per capita in Wales consider the long-term effects of Brexit and potential impacts of several shocks, such as the Covid-19 pandemic, inflation waves, disruption of the global supply chain, rising energy prices, and geopolitical conflicts. It is believed that all of these factors have contributed to the uncertainty of the current era and might continue having

impacts on economic growth in Wales. The NiGEM model also benefits from multiple schemes based on different scenarios of shocks with different levels of probability. Thus, we set up the following scenarios indicating different risks in the next five years (2024-2028): (1) the Ukrainian War will end in five years and the UK will not have another Brexit referendum; (2) the Ukrainian War will end in five years and the UK will have another Brexit referendum which decides the UK to return to the EU; (3) the Ukrainian War will not end in five years and the UK will have another Brexit referendum which decides the UK to return to the EU; (3) the Ukrainian War will not end in five years and the UK will have another Brexit referendum which decides the UK to return to the EU. We suppose that if there is another referendum that still maintains the current situation, there will only be temporary shocks that cause short-term impulse response of economic growth in the UK instead of having additional long-term risks, thus this scenario is omitted. Based on scenarios above, Figure 5.17 depicts the estimates of GDP per capita in Wales from 2024 to 2028 under three scenarios.



Figure 5.17 NiGEM Estimation of GDP per capita in Wales; 2024-2028

As is shown in the figure above, Scenario (1) shows steady increase in GDP per capita from 2024 to 2027 and such increase will be smaller in 2027-2028, indicating that the end of the Ukrainian War might have positive impacts on economic growth in the EU and UK including Wales. Scenario (2) shows fluctuations on GDP per capita in 2025-2026, potentially due to the temporary shock of the UK returning to the UK and relevant policy-related uncertainty. It is also believed that the probability of having another referendum is not necessarily low, given that recent polls show that 57% of British voters will vote to rejoin the EU if there were another referendum⁵⁰. However, few studies have paid attention to the possibility of the UK rejoining the EU and its potential impacts on the UK economy. Thus, this scenario might be significant

⁵⁰ https://www.reuters.com/world/uk/majority-britons-support-rejoining-eu-single-market-poll-2023-11-29/

to be more thoroughly examined in the future. Scenario (3) shows similar patterns of GDP per capita as for Scenario (1) with lower levels of GDP per capita, potentially due to the long-term negative effects of the Ukrainian War on global supply chain, energy prices, and the economic recovery around the world. It is also important to note that we have not included other shocks, negative ones such as the conflicts between the US and China, a possible war between China and Taiwan, and positive ones such as the progress of AI development and its impacts on increasing productivity. All of these shocks will be likely to affect GDP per capita and deserve to be analysed in the future.

5.7 Discussion and Conclusion

The main purpose of this chapter is to examine impacts of Brexit on major factors of the Welsh economy. To reach this purpose, this chapter decomposes such impacts into several aspects, i.e., international trade between Wales and other countries, inward FDI in Wales, and overall economic growth in Wales. These aspects are measured by the volume of imports and exports, the total value of inward FDI, and GDP per capita, respectively. Following the existing studies, we believe that international trade and inward FDI are two significant factors that might be impacted by Brexit and trigger the uncertainty of regional economic growth in the UK. Wales as an important component of the UK economy shares close economic relationship with the EU, indicating that it might suffer from significant changes in trade, FDI inflow, and local economic growth driven by Brexit. Main findings are outlined below:

(1) Trade. Based on the Synthetic Difference-in-Difference (DID) method, we find that the 2016 Referendum in 2016Q2 has had notable effects on the import and export dynamics of Wales. Specifically, it has considerably promoted the influx of goods from non-EU trading partners to Wales, while simultaneously discouraging exports from Wales to both EU and non-EU countries. The actual effectiveness of Brexit in 2021Q1 appears to exert minimal influence on the trade dynamics between Wales and its partners. Our observation suggests that factors previously identified in studies, such as the elucidation of details in Brexit-related trade policies, the completion of free trade negotiation between the UK and the EU, and the stabilization of trade flows between the UK and the rest of the world, may elucidate why the effects of Brexit on trade between Wales and its counterparts have diminished in significance since 2021. The high proportion and the resilience of Wales-EU trade since 2021 might explain why the impact of Brexit effectiveness on trade between Wales and other countries has found to be insignificant.

We also notice that, by comparing the actual data of trade in Wales and that in Doppelganger Wales since 2020, it seems that the Covid-19 pandemic is the main driver that caused fluctuations in imports and exports for Wales instead of Brexit, further indicating that impacts of Brexit on international trade might die down and the short-term impulse response of trade due to Brexit has been reduced. The author realised that it is possible that if large firms respond differently to treatment (e.g., Brexit) than smaller firms, the estimated average treatment effect may not represent the true effect on all firms. Large firms might have more resources to adapt (e.g., diversifying markets, absorbing shocks), leading to an over- or underestimation of the treatment effect. Thus, it is important to note that the current studies in this thesis in terms of DID analysis lack the focus on distribution of different levels of firms in Wales, which is a limitation and will be addressed in the future.

- (2) FDI Inflow. With the assistance of the SVAR Markov Regime-Switching model, we find that GDP growth rate in Wales, exchange rate of GBP-USD, inflation rate in the UK, and the country risk index are significant in determining FDI inflow in Wales during the sample period of 2011-2022. In this sample period, two Brexit-related events, i.e., the 2016 Referendum in 2016Q2 and the effectiveness of Brexit in 2021Q1, are considered as two turning points that divide the sample period into three regimes, which is used to examine impacts of Brexit on FDI inflow in Wales on different stages. By finalising the mechanism test, it is found that concerns over fluctuations in economic growth in Wales, exchange rates of pound sterling, and the growing political and economic risks in the UK might be potential mechanisms through which Brexit-related events have imposed negative impacts on the confidence of investment in Wales. In general, negative impacts of Brexit agreements.
- (3) GDP per capita. We use the Synthetic Control Method (SCM) to create a Doppelganger Wales based on macroeconomic data in three regions in France and Germany, all of which have very similar economic patterns as in Wales. It is also found that the 2016 Referendum dragged down the real GDP per capita in Wales compared to the ideal Doppelganger Wales which did not experience the referendum. Gaps in GDP per capita between real Wales and Doppelganger Wales started to be reduced in 2021, showing the diminishing marginal impacts of Brexit on economic growth in Wales. Finally, we use the NiGEM model and multiple scenarios to provide an initial estimate of GDP per

capita in Wales in next five years and further discuss several potential shocks such as the Ukrainian War and the possibility of another Brexit referendum.

These findings can also lead to several implications. First, it seems that the long-term impacts of Brexit on trade, inward FDI, and economic growth in Wales are not as significant as noted by the existing literature. Instead, several external shocks such as the Covid-19 pandemic and geopolitical conflicts in recent years have become major contributors that caused fluctuations in these variables. It requires the central government to take action to solve the problems of inflation, supply chain disruption, and other universal economic issues. Second, in accordance with the intention of Brexit, trade and other economic relationship between Wales and EU countries seems to be more severely affected since the 2016 Referendum, compared to non-EU countries. It encourages the Welsh government to de-risk the economic relationship between Wales and EU investment and increase trade between Wales and non-EU countries. Finally, regardless of external shocks, industrial upgrading, sustainable development, and application of new technologies are still major tasks in Wales to obtain economic growth in the future.

The analysis in this chapter is not without any limitations. First, due to data availability, all analysis on trade, inward FDI, and GDP per capita in Wales utilises macro-level data. However, if firm-level data in Wales can be used in our analysis, empirical findings might be more detailed. Second, the SCM benefits from the similarity of economic patterns between Wales and selected regions, but these regions still might have significant differences between the conditions in Wales. The PSM-DID method can to the maximum extent eliminate the bias due to the initial differences between the treatment and the control groups, which can also be utilised to analyse impacts of Brexit on economic growth in Wales and might reduce the bias existing in current SCM analysis.

Chapter 6 Revisit Brexit: Firm-Level Evidence in Wales

6.1 Literature Review

6.1.1 Corporate TFP in the UK and Wales

Total Factor Productivity (TFP) has been considered as an important measurement that shows the quality of economic growth in a certain economy. Specifically, it gauges productive efficiency by quantifying the amount of output generated per unit of inputs. TFP reflects the allocation of resources, the technological level of production methods, changes in production targets, the level of organizational management in production, the enthusiasm of workers for production and business activities, as well as the degree to which economic systems and various social factors influence production activities (Hulten, 2001). It has been widely acknowledged that, according to the Endogenous Growth Theory, economic growth primarily stems from internal factors rather than external forces and this theory emphasizes that investment in human capital, technological innovation, and knowledge plays a crucial role in fostering economic growth (Aghion et al., 1998). Additionally, the theory highlights the positive externalities and spillover effects associated with a knowledge-based economy, ultimately driving economic development. TFP as a major measurement of endogenous growth in this theory acts as a core variable to examine impacts of endogenous drivers such as innovation on economic growth. As such, TFP has been broadly utilised in numerous empirical studies that focus on impacts of external shocks on economic growth in economies such as China, UK, and Japan (Huang et al., 2019; Higon, 2007; Maskus & McDaniel, 1999).

Modern economic growth theory shows that TFP is the power source for corporate management and development. In recent years, firm-level or corporate TFP has become another popular measurement that demonstrates firm-level growth amid the background of regional economic growth. It refers to the efficiency and productivity of a corporation in generating output relative to its inputs, considering all factors of production such as labour, capital, and technology, and measures the overall effectiveness of a company in utilizing its resources to produce goods and services. It also reflects how efficiently a company converts inputs into outputs and is a key indicator of firms' performance and competitiveness in the market (Bournakis & Mallick, 2018). Corporate TFP has garnered more and more attention among economists since it offers a micro-level foundation of corporate growth to support the judgment of macro-level economic growth, especially for open economies (Dearden et al., 2000). Thus, there are rapidly growing empirical studies focusing on correlations between corporate productivity and public policies using corporate TFP as the dependent variable. The existing literature has listed several components that contribute to corporate TFP (Lagos, 2006; Crespo, 2008; Demir et al., 2022):

(1) *Labour productivity*. The effectiveness of labour in contributing to output generation in firms is a fundamental component of corporate TFP. It measures how efficiently workers can produce goods or services, often influenced by factors such as skills, training, motivation, education, and working conditions.

(2) *Capital efficiency*. The utilization and efficiency of capital resources (such as machinery, equipment, buildings) also play a crucial role in determining corporate TFP. Efficient allocation and management of capital assets can lead to higher productivity and output.

(3) *Technological innovation*. With the rapid development of technology such as AI in recent years, integrating cutting-edge technological innovation into production processes can have a profound impact on corporate TFP. By investing in research and development (R&D), adopting new technologies, and refining innovative processes, companies can boost productivity and competitiveness. It is also referred to as innovation spill-over effects for firms.

(4) *Improvements in management*. Effective management practices and organizational strategies can influence corporate TFP. Good governance, strategic decision-making, operational efficiency, and resource allocation strategies all contribute to improving overall productivity.

(5) *Quality of outputs*. The quality and suitability of inputs (such as raw materials, components, and supplies) can affect TFP. Using high-quality inputs can usually lead to better output quality and overall productivity.

(6) *External factors*. Economic conditions, public policies, regulatory environment, market competition, and external shocks (such as technological disruptions or financial crises) can also influence corporate TFP by affecting business operations and investment decisions.

Regarding corporate productivity in the UK, Figure 6.1 shows the historical trend of UK's corporate TFP from 2008 to 2019, which shows that the revenue weighted corporate TFP for firms in the manufacturing industry decreased from 1.1 in 2008 to 0.8 in 2019, showing the declining general trend of corporate productivity for the manufacturing industry in the UK. It is consistent with several studies, such as Godley (2023) who claims that the manufacturing output in the UK has increased significantly less than the output of other goods and services. Harris and Moffat (2019) take a more relevant approach to analyse the manufacturing growth

in the UK from 1973 to 2012 using firm-level TFP and demonstrate the decline of this industry in past decades. However, we also find that the revenue weighted corporate TFP for firms in other industries, especially in the service sector, has experienced significant increase during the same period, potentially due to the strong growth in financial services, retailing, and education in past decades and the dominant position of the service sector in the UK economy.



Figure 6.1 Corporate TFP trends in the UK

Notes: The left figure shows the revenue weighted corporate TFP for manufacturing industry and the right figure shows the revenue weighted corporate TFP for other industries. Sources: The Office for National Statistics (ONS) Annual Business Survey and estimates provided by Coyle et al. (2023).



Figure 6.2 Corporate TFP trends in Wales, logged

Notes: Data source includes firm-level Bureau Van Dijk FAME database, the ONS Annual Business Survey data related to firms in Wales, and the ONS Labour Force Survey data related to firms in Wales. Corporate TFP estimates in Wales are based on calculation methods provided by ONS.

Figure 6.2 illustrates the trend of corporate TFP (logged) for firms in Wales from 2008 to 2023, based on multiple databases and final estimates by the author. The specific calculation method will be introduced in the following sections. From this figure, we can observe that corporate

TFP (logged) increased from 0.2 in 2008 to 0.39 in 2023 and presents a generally steady rise in the past 15 years. It is also crucial to highlight two specific periods, i.e., 2016-2018 and 2020-2021, when corporate TFP in Wales experienced significant decline, potentially due to the 2016 Brexit Referendum and the Covid-19 pandemic, respectively. Another decline period, i.e., 2012-2014, is consistent with the trend of corporate TFP in the UK as shown in Figure 6.1, which might result from the shock of European Debt Crisis on the overall UK economy when the UK-EU trade and FDI from the EU experienced extraordinarily negative impacts (Beker, 2014).

6.1.2 Policy Shock and Corporate TFP

Corporate TFP is very likely to have volatility due to policy shocks no matter whether such policy shocks are positive or negative. Mayer et al. (2016) apply the robust sign restrictions approach and a VAR framework to analyse how firm-level TFP will respond to policy shocks and find that TFP increases in response to positive supply, demand, and wage mark-up shocks and does not significantly respond to monetary policy shocks. They claim that TFP fluctuates endogenously when policy shocks apply in accordance with the business cycle based on empirical evidence.

More specifically, regarding public policies, Li et al. (2022) find that the industrial policy that encourages digital transformation in China driven by the Twin Transition (Green Transition and Digital Transition) Strategy significantly leads to rising corporate TFP and such positive impact is more pronounced for firms with higher ESG initial performance. Chen (2022) analyses impacts of the national smart city pilot (SCP) policy on corporate TFP in China and illustrates that the SCP can significantly increase the TFP of firms and such impact varies in firms with different ownerships, locations, and managerial structures. Everaert et al. (2015) estimate the direct and indirect effects of fiscal policy shocks on firm-level TFP in a panel of OECD countries in 1970-2012 and find that budget deficits harm TFP, a shift toward productive fiscal expenditures will significantly encourage TFP while a shift toward social transfers will reduce TFP.

In addition, with regard to trade policies, Abizadeh and Pandey (2009) investigate impacts of trade openness on growth of corporate TFP and find that an open trade environment will have overall positive impacts on corporate TFP and the services sector benefits most from trade openness while the agricultural and industrial sectors seem not have received significant effects from such environment. This study presents a valuable reference since trade has played a

significant role in the UK economy and output provided by the services sector accounts for over 80% among all sectors in the UK⁵¹. Shu and Steinwender (2019) also find that trade liberalisation will result in higher-level corporate productivity. Dovis and Milgram-Baleix (2009) examine the sensitivity of corporate TFP to trade openness and tariffs in Spain and illustrate that corporate TFP is negatively impacted by European tariffs and other trade barriers since more fierce competition due to increasing foreign products in the domestic market and firm imports will encourage innovation and product upgrades, thus lead to improvements in corporate TFP. Yu (2015) also finds that both import and export tariffs discourage improvements in firm-level productivity in China. In the UK, there is also evidence that shows positive correlations between trade and corporate productivity (Harris & Moffat, 2015).

Investment, especially FDI, can have critical impacts on corporate TFP as well. Li and Tanna (2019) analyse correlations between inward FDI and firm-level TFP growth based on data for 51 developing countries in the period 1984-2010 and find that inward FDI and corporate TFP are significantly correlated if the roles of human capital and institutions as contingencies are considered. They also claim that the rapidly growing inward FDI boosted by opening-up policies in developing countries can significantly contribute to corporate productivity growth, according to historical data and their empirical evidence. Tsamadias et al. (2019) also find that FDI has a positive impact on TFP for firms in non-European OECD countries. Baltabaev (2014) adds that shorter distances to FDI countries of birth with frontier technology will make such impact more remarkable in the FDI inward regions. Turning to the case of the UK, Harris and Moffat (2013) find that FDI contributed to the aggregate TFP in the UK for 1997-2008 and foreign-owned plants contributed relatively more to aggregate corporate productivity growth than UK-owned plants. Haskel et al. (2007) focus on impacts of FDI on corporate productivity in the manufacturing sector and suggest a robust and significantly positive correlation between a domestic plant's TFP and the foreign-affiliate share of activity. However, in recent years, there are quite few studies on how corporate TFP responds to public policy shocks through mechanisms of trade and FDI in the UK based on firm-level data, where this study can fill these gaps hopefully.

Brexit as a policy shock has been considered to have caused negative impacts on corporate TFP in the UK. For instance, Reenen and Yang (2023) refer to historical firm-level data of productivity and find that Brexit has led to inferior corporate TFP for firms in the UK compared

⁵¹ See the Research Briefing of Service Industries: <u>https://commonslibrary.parliament.uk/research-briefings/sn02786/</u>

to firms in France, Germany, and the US. Bloom et al. (2019) find that firm-level productivity was depressed by Brexit due to growing concerns over economic uncertainty related to Brexit, and firms that are more exposed to international trade, owned by EU countries, and belong to sectors that rely heavily on the UK-EU trade are more likely to suffer from corporate TFP decline due to Brexit. Nevertheless, it is important to note that, to the best of the author's knowledge, relevant studies on the impacts of Brexit on corporate TFP in the UK and its regions with firm-level data are extremely inadequate. It does not mean that discussions on how Brexit affected the aggregate TFP in the UK are scarce, given that multiple studies have revealed that, on a macro level, Brexit and its relevant uncertainty of UK-EU trade, FDI to the UK, and broader socioeconomic risks in the UK will bring negative impacts on the UK economy measured by aggregate TFP (McGrattan & Waddle, 2020; Broadbent et al., 2023; Fingleton et al., 2023). These discussions still provoke insights into potential mechanisms through which Brexit can affect corporate TFP, such as trade, FDI, and corporate ownership. This section aims to unprecedentedly analyse impacts of Brexit on corporate TFP in Wales based on firm-level data to provide insight into such impacts in the UK since the Welsh economy is an important component of the UK economy and it heavily relies on trade with EU countries and investment from the EU region.

Inward migration from outside of the UK might be another channel that can moderate impacts of Brexit on corporate TFP in Wales. As is discussed in Chapter 3, sufficient studies have revealed that Brexit will have negative impacts on inward migration to the UK, especially EU migration, which might lead to shortage of foreign labour and skills, lack of innovation, and deterioration of inclusive and diverse work environments. These impacts could result in lower corporate productivity and inferior competitiveness of businesses in the UK.

Finally, although seldomly discussed in the UK, impacts of Brexit on corporate TFP should present spatial and corporate heterogeneity due to multiple reasons including differences in initial levels of local economic growth and firms' own business performance. The heterogeneity issue in the topic of how corporate TFP responds to policy shocks is thoroughly discussed in China. For instance, Liu et al. (2021) reveal that the financialization project of manufacturing enterprises will have heterogeneous impacts on corporate TFP in China, i.e., firms with initially higher TFP and private ownership will benefit more from the project than other kinds of firms. Zhang and Du (2020) claim that firms in more developed regions and with higher-level green technology will receive more significant effects on corporate TFP from the

Green Development strategy in China. As such, this study will also try to examine the potential heterogeneity of impacts of Brexit on corporate TFP in Wales.

6.1.3 Hypotheses

Following previous discussions and literature review, the following hypotheses for this study will be analysed:

(1) Brexit is estimated to have had significant impacts on corporate TFP in Wales.

(2) Such impacts will show spatial and corporate heterogeneity among firms in Wales.

(3) Mechanisms of trade, FDI, and inward migration contribute to such impacts, i.e., Brexit affected corporate TFP in Wales through the channels of the UK-EU trade, FDI from the EU, and inward migration from other countries.

6.2 Methodology

6.2.1 Empirical Method

This study comprises two empirical methods to provide robust analysis, the panel data with FE model which only analyses impacts of Brexit on corporate TFP for firms in Wales, and the PSM-DID method which tries to provide comparative analysis on corporate TFP for firms in Wales by comparing it with corporate productivity for firms in Brittany, a French region which shares extremely similar macroeconomic and industrial patterns with Wales.

First, the author established the following empirical model:

$$CTFP_{it} = \alpha_0 + \alpha_1(U_i \times Post_t) + \gamma X_{it} + f_i + m_t + \varepsilon_{it}$$
(27)

where $CTFP_{it}$ stands for the corporate TFP for firm *i* in year *t*; the coefficient α_1 measures the impacts of Brexit on corporate TFP for firms in Wales; U_i represents the extent of Brexit exposure for each firm in Wales, measured by the Brexit Uncertainty Index; $Post_t$ is a Brexit dummy variable which equals to 1 if *t* is larger than 2016 since the Brexit Referendum is considered to have brought significant economic uncertainty to firms in the UK, as discussed in previous sections; $U_i \times Post_t$ is the core independent variable in the form of an interaction term that denotes how and when each firm in Wales was impacted by Brexit; X_{it} is a set of firm-level control variables; f_i and m_t are firm and year fixed-effect terms; ε_{it} is the random error term.

It is important to highlight that in this DID model, the local-council or city control variable is not included due to lack of local-council-level macroeconomic data in Wales. Although it is possible that economic growths among different local councils in Wales might vary, the author believes that the set of firm-level control variables can eliminate sample selection bias and other potential statistical bias as much as possible due to the large amount of samples and adequate variables that measure firms' business performance.

Second, this study also includes PSM-DID analysis by comparing corporate productivity of firms in Wales and Brittany to provide another empirical evidence and make results of this study more robust. The PSM-DID model is as follows:

$$CTFP_{it} = \beta_0 + \beta_1 (Treat_i \times Post_t) + \gamma X_{it} + f_i + m_t + \varepsilon_{it}$$
(28)

where $CTFP_{it}$, X_{it} , f_i , m_t , and ε_{it} denote the same meanings as in Equation (27). The current interaction term, $Treat_i \times Post_t$, represents whether the firm *i* was directly impacted by Brexit in year *t*, where $Treat_i$ will equal to 1 if this firm is located in Wales and 0 if this firm is in Brittany, and $Post_t$ will equal to 1 if *t* is larger than 2016. Thus, the coefficient of this interaction term reflects the impact brought by Brexit directly by comparing corporate TFP for firms in Wales and Brittany, i.e., between the UK and France. The author uses the PSM-DID method since the use of the DID method requires a crucial precondition that the treatment group and the control group exhibit a common trend (Rosenbaum & Rubin, 1983). This means that without the policy shock of Brexit, there should be no systematic difference in the overall change trend of listed companies in Wales and Brittany over time. However, in reality, significant regional disparities still exist if all socioeconomic factors are considered in these two regions, rendering this assumption often inadequate. Thus, this study employs the more advantageous PSM-DID method to account for unobservable differences that do not vary over time between groups, thereby deriving impacts of policy shock of Brexit. Detailed illustrations of PSM practice and results of regression will be introduced in the appendix.

6.2.2 Variables

6.2.2.1 Dependent Variable

The dependent variable of this study is corporate TFP. There are three primary approaches used in academic research to calculate Total Factor Productivity (TFP). The initial approach falls under the parameter method, exemplified by Solow's residual method and Stochastic Frontier Analysis (Fuentes & Morales, 2011). However, the stochastic frontier function's functional form and distribution assumptions are often too stringent for practical application. The second type encompasses non-parametric methods like the Data Envelope Analysis (Danquah et al., 2014; Zhu et al., 2018), which relies entirely on data-driven techniques.

The final approach is the semiparametric method, typified by the Olley-Pakes (OP) and Levinsohn-Petrin (LP) methods (Levinsohn & Petrin, 2003). This method involves first estimating the coefficients of independent variables to discern the influence of state variables on intermediate inputs versus outputs. Subsequently, this method estimates the coefficients of state variables and independent variables and can effectively address endogeneity and sample selection bias issues arising from the correlation of TFP within residual input factors. Numerous studies on impacts of policy shocks on TFP have applied the LP method due to patterns of firm-level data. Thus, this study adopts the LP method to proceed with empirical analysis.

The essential idea of the LP method is to utilise the intermediate input of a firm as a proxy variable for corporate TFP. It assumes that the firm makes business decisions based on current productivity of this firm. Equation (29) shows the typical relationship between enterprise input and output, where y_{it} represents corporate output; W_{it} represents the free variable measured by payroll reflecting the cost of labour; X_{it} is a state variable often measured by enterprise capital; ω_{it} denotes the corporate TFP; ε_{it} is the white noise.

$$y_{it} = \alpha + \beta W_{it} + \gamma X_{it} + \omega_{it} + \varepsilon_{it}$$
(29)

According to Levinsohn and Petrin (2003), corporate TFP can thus be estimated by Equation (30). LP method assumes that corporate TFP conforms to the first-order Markov process, where $\Omega_{i,t-1}$ means the decision information set and ξ_{it} is productivity shock which is irrelevant to corporate TFP and state variables.

$$\omega_{it} = E(\omega_{it}|\Omega_{i,t-1}) + \xi_{it} = E(\omega_{it}|\omega_{i,t-1}) + \xi_{it}$$
(30)

LP method also assumes that the intermediate input M_{it} depends on X_{it} and ω_{it} while M_{it} will increase monotonously with X_{it} and ω_{it} . Equation (32) can be derived from Equation (31).

$$M_{it} = f(X_{it}, \omega_{it}) \tag{31}$$

$$\omega_{it} = f^{-1}(M_{it}, X_{it}) = h(M_{it}, X_{it})$$
(32)

Then, insert Equation (32) into Equation (29) to get Equation (33) below, where $\varphi_{it}(M_{it}, X_{it})$ is equal to $\gamma X_{it} + h(M_{it}, X_{it})$.

$$y_{it} = \alpha + \beta W_{it} + \varphi_{it}(M_{it}, X_{it}) + \varepsilon_{it}$$
(33)

As is shown in Equation (33), a third-order polynomial containing the M_{it} and X_{it} is replaced by the term $\varphi_{it}(M_{it}, X_{it})$. Thus, Equation (33) can be estimated by OLS to obtain estimated coefficient $\hat{\beta}$ of W_{it} , so that Equation (34) can be derived, where $\eta_{it} = \xi_{it} + \varepsilon_{it}$.

$$y_{it} - \hat{\beta}W_{it} = \alpha_0 + \gamma X_{it} + \omega_{it} + \varepsilon_{it}$$

= $\alpha_0 + \gamma X_{it} + E(\omega_{it}|\omega_{i,t-1}) + \xi_{it} + \varepsilon_{it}$
= $\alpha_0 + \gamma X_{it} + E(\omega_{it}|\omega_{i,t-1}) + \eta_{it}$ (34)

Construct $\widehat{\omega}_{it} = \delta_0 + \delta_1 \omega_{i,t-1} + \delta_2 \omega_{i,t-1}^2 + \delta_3 \omega_{i,t-1}^3 + \theta_{it}$ to calculate the nonparametric consistency estimate of expected value $\widehat{E}[\omega_{it}|\omega_{i,t-1}]$. Since we have known $\widehat{\omega}_{it} = \widehat{\varphi}_{it} - \gamma X_{it}$ and $\widehat{\omega}_{i,t-1} = \widehat{E}[\omega_{it}|\omega_{i,t-1}] + \xi_{it}$, these two equations can be inserted into Equation (34) and we can get Equation (35).

$$y_{it} - \hat{\beta}W_{it} = \alpha_0 + \gamma X_{it} + \hat{E}[\omega_{it}|\omega_{i,t-1}] + \xi_{it} + \varepsilon_{it}$$
(35)

Thus, the residual $\eta_{it} = \xi_{it} + \varepsilon_{it}$ can be obtained from Equation (35), which is corporate TFP:

$$\eta_{it} = y_{it} - \hat{\beta}W_{it} - \alpha_0 - \gamma X_{it} - \hat{E}[\omega_{it}|\omega_{i,t-1}]$$
(36)

Following Bournakis and Mallick (2018), this study utilizes logarithmic transformations of key business indicators to assess enterprise performance: the logarithm of main operational income gauges output; the logarithm of the sum of net fixed assets and construction in progress measures enterprise capital stock; the logarithm of employee count estimates labour input; and the logarithm of operational costs and expenses minus depreciation quantifies intermediate input. The OP method requires a prerequisite of monotonically increasing investment and productivity, meaning that samples lacking investment cannot be estimated—a criterion not met by every company annually due to variable investment patterns. The Levinsohn-Petrin (LP) method, however, builds upon the OP method by substituting intermediate input for direct investment as a proxy variable, thus enabling researchers to flexibly select proxy variables tailored to specific analytical needs.

6.2.2.2 Independent Variable

For the panel data model, the independent variable is $U_i \times Post_t$ in the form of an interaction term that denotes how and when each firm in Wales was impacted by Brexit. U_i comes from the Brexit Uncertainty Index (BUI) which combines the BUI data released by Bank of England in 2016-2019 (Bloom et al., 2019) and the BUI data released by Chun et al. (2023) from the University of Birmingham in 2013-2019. More specifically, the BUI from Bank of England is obtained from the Decision Maker Panel survey which asks, "How much has the result of the EU referendum affected the level of uncertainty affecting your business" with four possible responses: (1) 'Not important', (2) 'One of many drivers of uncertainty', (3) 'One of the top two or three drivers of uncertainty', and (4) 'The largest current source of uncertainty'. They use this to generate our key Brexit Uncertainty Index (BUI), which is defined as the share of firms which choose options (3) or (4), which rates Brexit as, at the least, one of the three highest drivers of uncertainty for their business. The BUI by Chun et al. (2023) consists of multiple novel news-based indicators of Brexit uncertainty at both aggregate and topic-specific level for the UK economy and business environment based on textual analysis and machine learning methods. They also include data analysis on key words of Brexit and business uncertainty in news, business reports, corporate annual reports, and social media in the UK to estimate how business owners responded to Brexit and relevant concerns.

For the PSM-DID analysis, the independent variable is the Brexit dummy which presents in the form of $Treat_i \times Post_t$ representing whether the firm *i* was directly impacted by Brexit in year *t*, where $Treat_i$ will equal to 1 if this firm is located in Wales and 0 if this firm is in Brittany, and $Post_t$ will equal to 1 if *t* is larger than 2016.

6.2.2.3 Moderating Variables

As is discussed in previous sections, numerous scholars have found that Brexit might have caused significant effects on FDI inflow to the UK, international migration to the UK, and international trade for the UK with its trade partners, especially EU countries. These impacts are likely to result in fluctuations in business owners' perception and capability of future operation and thus firm-level performance and productivity, which makes FDI inflow, inward migration, and trade become three potential mechanisms through which Brexit can impact corporate TFP. Meanwhile, whether these channels have moderating effects on corporate TFP for individual firms in Wales depends on whether firms are vulnerable to Brexit. Hence, this study incorporates FDI inflow, inward migration, and trade into the benchmark model and establishes a set of equations that perform the mechanism tests.

6.2.2.4 Control Variables

Economic development status and local economic growth might significantly impact corporate productivity in a certain region (Ding et al., 2016). Meanwhile, initial business performance

and endowments might affect the development of corporate TFP for firms as well (Duguet, 2006). Therefore, this study uses several control variables that belong to both macro level and corporate level: (1) on the macro level, they include GDP per capita, unemployment rates, inflation rates, FDI inflow, and total trade volumes in Wales; (2) on the corporate level, they include total revenue, return on asset, net profit margin, number of employees, capital-output ratio, current ratio represented by the debt-to-asset ratio, and the length of business operation.

6.2.3 Research Area

The research area of this study covers all 22 local authorities in Wales since each local authority has at least one sample firm according to the database utilised for this study. As is discussed, local-authority-level data of local economic growth in Wales is inadequate so that data for macro-level control variables is on the level of Wales instead of local authorities. As more regional economic data becomes available, this may enable further studies to be conducted.

6.3 Data

Data of essential variables to calculate corporate TFP for firms in Wales comes from the FAME database which is provided by Bureau Van Dijk (BVD) using data on the population of UK firms from the UK Companies House and is part of the global AMADEUS database. It is a comprehensive source of firm-level financial and business information for thousands of firms in the UK and Ireland. This database provides a series of corporate data including:

(1) *Company information*: Detailed profiles of companies including financials, ownership structures, industry classifications, and contact details.

(2) *Financial statements*: Access to balance sheets, income statements, cash flow statements, and other financial metrics for companies.

(3) *Company performance metrics*: Analysis tools and metrics to assess company performance and financial health.

(4) Ownership Information: Details on company ownership, subsidiaries, and group structures.

(5) Market Data: Information on market trends, industry analysis, and sector performance.

FAME database has been utilised by multiple empirical studies on firm-level productivity and corporate performance. For instance, Hutchinson et al. (2022) use the FAME data to analyse impacts of private hedge fund on corporate incentives and performance. Breinlich et al. (2020) use the FAME data to verify the robustness of publicly-reported firm-level trade data. Lavery

et al. (2024) focus on impacts of private equity buyouts on export activity for firms in the UK during the Brexit period, 2012-2019, using the FAME dataset. This study follows Lavery et al. (2024) and uses the FAME data in 2013-2019 with the key time point of 2016 included when the Brexit Referendum was held. This period is suitable for analysis on impacts of Brexit on corporate TFP since time periods of pre- and post-Brexit-Referendum are evenly distributed and potential impacts of the Covid-19 pandemic on corporate productivity can be avoided. Removing firms with missing data or discontinued operation, the author compiled a panel consisting of 123,372 sample firms spanning the period from 2013 to 2019.

The FAME database provides limited coverage of certain domestic and multinational firms with operations and trading addresses in Wales but headquartered elsewhere. However, for the purposes of this analysis, the FAME data offers a representative sample of multinational firms with registered offices in Wales, as well as comprehensive information on the substantial number of SMEs that constitute the majority of businesses in the region. While it is acknowledged that SMEs dominate the business count, their contribution to GVA is relatively smaller (refer to the attached Size Analysis of Active Businesses in Wales⁵², 2023). Despite its limitations, the FAME database remains the most suitable and currently available source for estimating TFP.

According to users guide of FAME database, the data relate to all firms operating in Wales, including Welsh-headquartered firms and MNCs operating in Wales. Although there are several significant MNCs in Wales, the majority of firms in Wales are mid-level and small enterprises, and the issue of potential bias caused by MNCs can be hopefully eliminated in the following robustness tests by emitting extreme data (outliers).

For the comparative study on firms in Wales and Brittany based on PSM-DID analysis, the author uses one of the most comprehensive firm-level data sources in France, the SIRENE database, to extract firm-level data of the same variables during the same period. SIRENE is the official database of corporate performance provided by the French National Institute of Statistics and Economic Studies (INSEE) and includes thousands of corporate records such as company information, financial status, market performance, and operational structures⁵³. The same 123,372 sample firms in Brittany from 2013 to 2019 are extracted to match the sample size of firms in Wales. It is also important to note that during the process of matching firm-

⁵² https://www.gov.wales/size-analysis-businesses-2023

⁵³ See the official website of SIRENE (in French): <u>https://www.data.gouv.fr/fr/datasets/base-sirene-des-entreprises-et-de-leurs-etablissements-siren-siret/</u>.

level data in these two regions, the sampling procedure is totally random so that sample bias can be reduced to minimum.

Data for corporate-level control variables also comes from FAME and SIRENE databases. Data for regional control variables in Wales relies on the ONS annual data of multiple variables that measure economic growth in Wales and Welsh Government Statistics that include annual reports of the Welsh economy. Data for regional control variables in Brittany relies on the section of regional economic statistics (statistiques régionales) from National Institute of Statistics and Economic Studies (INSEE) in France, annual economic reports provided by Regional Chamber of Commerce and Industry (CCI) of Brittany, and regular statistics of local economic growth released by Bank of France (Banque de France).

6.4 Results and Discussions

6.4.1 Descriptive Statistics

The descriptive statistics of all variables for the benchmark model are summarised in Table 6.1 and non-percentage continuous variables are taken in the logarithmic form.

Variables	Mean	S.D.	Min	Max	Operationalization
lnCTFP	0.383	1.219	0.151	0.675	Corporate TFP, logged
Ui	0.593	0.204	0.513	0.652	Brexit Uncertainty Index
Post _t	0.521	0.034	0	1	Brexit identification term
Macroeconom	ic control varid	ables			
lnGDP	4.285	0.078	3.971	4.586	GDP per capita in Wales, logged
UR	0.072	0.023	0.031	0.095	Annual average unemployment
					rate in Wales
IR	0.062	0.046	0.048	0.074	Annual average inflation rate in
					the UK
lnFDI	7.289	0.108	6.628	7.856	FDI values in Wales, logged
lnTrade	8.003	0.098	7.745	8.329	Total trade volumes, logged
Firm-level co	ntrol variables	5			
lnRevenue	5.457	1.663	3.232	8.433	Total revenue, logged
ROA	0.673	1.554	0.231	1.114	Return-on-Asset ratio
NPM	0.328	2.205	0.123	0.506	Net profit margin ratio
lnN	2.655	2.567	1.033	4.478	Number of total employees,
					logged

Table 6.1 Summary statistics and operationalizations

COR	0.852	1.456	0.571	1.138	Capital-Output ratio
DAR	0.762	1.562	0.486	0.997	Debt-to-Asset ratio
lnLife	1.206	3.378	0.482	2.079	Number of years of operation,
					logged
IV-related va	riables				
SaleEU	0.671	1.744	0.333	0.927	Share of sales to the EU
EULabour	0.127	1.323	0.076	0.198	Share of EU migrants in the firm
EUOwner	0.012	3.672	0	1	EU ownership dummy (1=owned
					by EU countries, 0 otherwise)

Note: 1. The data for share of sales to the EU, share of EU migrants among all employees, and EU ownership comes from the FAME database and the Labour Force Survey (LFS) database. 2. Three EU-related variables are for the IV estimation.

As shown in this table, the average performance of corporate TFP for sample firms is consistent with the data of corporate TFP for all firms in Wales shown in Figure 6.2. Brexit Uncertainty Index has the range from 0 (minimum) to 100% (maximum) and data of BUI shows that firms in Wales universally have relatively high-level concerns over business uncertainty due to Brexit. For macroeconomic control variables, all of them show little fluctuation during the sample period. For firm-level control variables, it can be found that data of several variables such as the number of employees, length of operation, and net profit margin vary significantly among sample firms. In addition, to perform the IV analysis that examines heterogeneous impacts of Brexit on firms with frequent or infrequent business connections with EU countries, data of three EU-related variables is also included. Data of share of sales to the EU shows that numerous firms in Wales share close trade contact with the EU region.

6.4.2 Baseline Analysis

The results of the baseline regression of the DID model are presented in Table 6.2. As is shown in this table, columns (1)-(5) represent results of two OLS analysis, two FE analysis, and IV estimation based on the benchmark model. Specifically, column (1) shows results of basic OLS without control variables. As the error term might contain control variables that influence the corporate TFP, column (2) introduces control variables on both macroeconomic and corporate levels on the basis of column (1). The regression results are then obtained by controlling for year FE as shown in column (3) and controlling for year, firm, and region (macroeconomic growth) FE as shown in column (4). Column (5) illustrates results of IV estimation by adding three EU-related instrumental variables to examine whether firms with closer economic ties with the EU suffered more corporate TFP loss from Brexit.

Results indicate that: (1) Brexit uncertainty after the 2016 Referendum is significantly and negatively correlated with corporate TFP for firms in Wales under all regression circumstances; (2) During the sample period (2013-2019), growth in GDP per capita, FDI inflow, and trade seem to have significant impacts on improving corporate TFP and reducing negative impacts of the Brexit shock on corporate performance in Wales; (3) Firms with higher revenue, return-on-asset, net profit margin, capital-output ratio, and lower debt-asset ratio, and longer life of operation seems to have higher corporate TFP than other firms; (4) IV analysis shows that for firms with higher proportions of sales to the EU, more EU labour migrants, and EU ownership, corporate TFP will be more significantly discouraged by Brexit. The firm-level heterogeneity of EU-related variables will be further analysed in the next section.

Results above are highly consistent with existing literature in the following aspects: (1) the 2016 Referendum and its outcome have caused significant concerns over uncertainty of the economic and business environment in the UK and corporate productivity was negatively impacted by Brexit since firms tended to reduce or postpone investment, reduce recruitment, and transfer capacity of production to de-risk from Brexit (Hill et al., 2019), which seems to also have happened in Wales; (2) Macroeconomic data shows that the Welsh economy remains relatively strong since the 2010s, especially that GDP per capita, international trade, and FDI inflow steadily increased, which acts as a counteracting effect that smoothened the shock of Brexit; (3) The theory of economies of scale highlights the cost and productivity advantages that firms can achieve as their scale of production increases (Stigler, 1958) and this study provides empirical evidence to support this theory; (4) Multiple studies have revealed that firms with close economic contact with EU countries or EU ownership in the UK might be impacted more severely by Brexit as discussed above, and our empirical results based on the benchmark model provide another evidence by using the case of firms in Wales.

Dependent Variable	TFP: OLS1	TFP: OLS2	TFP: FE1	TFP: FE2	TFP: IV
	(1)	(2)	(3)	(4)	(5)
$U_i \times Post_t$	-0.247***	-0.328***	-0.204***	-0.221***	-0.397***
	(0.345)	(2.614)	(0.994)	(1.032)	(2.634)
lnGDP		0.543***		0.423***	0.327**
		(-3.329)		(5.742)	(2.339)
UR		-0.034		-0.037	-0.021
		(0.456)		(2.726)	(0.997)

Table 6.2 Baseline regression results

IR		0.021	0.035	0.038	
		(1.477)		(1.287)	(0.305)
lnFDI		0.108***		0.102***	0.112***
		(2.034)		(3.338)	(0.027)
lnTrade		0.127***	0.104***	0.118***	
		(1.002)	(2.089)	(0.977)	
lnRevenue		0.562**		0.533**	0.572**
		(-1.378)	(1.776)	(2.544)	
ROA		0.327**		0.301**	0.311**
		(1.303)		(4.467)	(2.646)
NPM		0.018**		0.015**	0.016**
		(0.412)		(1.003)	(0.564)
lnN		0.125		0.103	0.127
		(5.892)	(0.789)	(1.346)	
COR		0.036**		0.033**	0.030**
		(1.873)	(0.912)	(1.435)	
DAR		-0.005**	-0.004**	-0.007**	
		(4.198)	(2.659)	(-1.728)	
lnLife		0.028**		0.021**	0.017**
		(3.902)		(4.698)	(0.345)
IV regression results					
SaleEU		1.744		0.927	0.201**
					(0.023)
EULabour		1.323		0.198	0.346**
					(1.766)
EUOwner		3.672		1	0.156**
					(0.048)
Constant	1.205***	0.467***	1.023***	0.683***	0.902***
	(5.673)	(-2.689)	(4.238)	(-1.127)	(0.835)
Year FE	No	No	Yes	Yes	Yes
Firm FE	No	No	No	Yes	Yes
Region FE	No	No	No	Yes	Yes
Observations	986,976	986,976	986,976	986,976	986,976
R-squared	0.034	0.532	0.367	0.602	0.568

Note: ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

6.4.3 Heterogeneity Analysis

Considering remarkable gaps in economic growth and business development among different regions in Wales, the spatial heterogeneity analysis is conducted. Columns (1) to (4) of Table 6.3 report the results of the spatial heterogeneity test, which confirm the existence of significant regionally heterogeneous effects of Brexit on corporate TFP. Note that according to the official categorization of the Welsh government⁵⁴, Wales can be divided into four areas, i.e., North Wales consisting of 6 local councils, Mid Wales consisting of 2 local authorities, Southwest Wales consisting of 4 local councils, and Southeast Wales consisting of 10 local authorities.

Results of spatial heterogeneity test show that firms in Southwest and Southeast Wales receive more significant impacts of Brexit on corporate TFP than other regions of Wales, potentially due to these two regions having relatively higher-level economic development and business environment with close economic connections with the EU region. The coefficient for firms in Southeast Wales is the most significant, consistent with several studies showing that this region, especially the Cardiff Capital Region and its contiguous local authorities, provides the majority of economic growth and productivity in Wales and owns numerous firms that have frequent trade, labour, and capital exchange and cooperation with the EU region (Alden & Essex, 2014). Knight et al. (2017) and Mallet-Garcia et al. (2022) also find that this region is one of the most important migration destinations for EU migrants in the UK and the proportion of EU labour for firms in this region is notably high, which offers another potential reason for significant impacts of the Brexit shock on corporate TFP.

Variable	North Wales	Mid Wales	S.W. Wales	S.E. Wales
	(1)	(2)	(3)	(4)
$U_i \times Post_t$	-0.135*	-0.167	-0.205**	-0.221***
	(1.736)	(3.729)	(2.343)	(0.477)
Constant	0.789*	1.347	1.018**	1.219***
	(1.328)	(3.104)	(0.089)	(1.248)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	185,438	106,782	263,693	431,063
R-squared	0.208	0.437	0.689	0.546

Table 6.3 Spatial heterogeneity test results

⁵⁴ See for example, the Statistical Release in 2020 by the Welsh government: <u>https://www.gov.wales/sites/default/files/statistics-and-research/2020-05/summary-statistics-regions-wales-2020-629.pdf</u>

Note: ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively. Coefficients of firm and region control variables are emitted.

In addition, following Chadha and Berrill (2021), the firm heterogeneity test is constructed to examine whether firms with closer economic ties with the EU will be more significantly impacted by Brexit with regard to corporate TFP. Columns (1) to (3) of Table 6.4 reveal the results of heterogeneity test for firms with sales to the EU occupying at least 50% in the total sales volume, with EU labour occupying at least 50% in total non-UK employees, and with EU ownership, respectively. As shown in this table, coefficients for firms in all categories are significant and the absolute values of these coefficients are extremely larger than coefficients in Table 6.2, indicating that firms with high proportions of sales to the EU or EU labour or owned by EU countries experience more remarkable decline in corporate TFP due to Brexit.

These findings also echo the existing literature in the following aspects: (1) Brexit agreements include additional restrictions and barriers to the UK-EU trade, such as additional customs checks, tariffs on goods and services, and regulatory divergence, which might have negative impacts on EU-oriented firms in the UK (Buigut & Kapar, 2023); (2) EU labour migrants now have to apply for workers' visas and losing the right of free movement might reduce the number of EU migrants to the UK, thus discouraging firms in the UK from obtaining labour resources and innovation brought by EU migrants (Simionescu et al. 2017); (3) Firms with EU ownership in the UK will experience reluctance of investment and business expansion, supply chain disruptions, market volatility, and more trade barriers due to Brexit, thus corporate TFP of these firms might face higher risks (Lin & Chen, 2020).

Variable	Sales to EU	EU labour	EU owned
	(1)	(2)	(3)
$U_i \times Post_t$	-0.479***	-0.893***	-0.683***
	(6.215)	(3.336)	(0.846)
Constant	0.209***	0.367***	0.284***
	(0.263)	(3.101)	(1.261)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Observations	83,604	53,099	34,995
R-squared	0.403	0.496	0.365

Table 6.4 Firm heterogeneity test results

Note: ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively. Coefficients of firm and region control variables are emitted.

6.4.4 Mechanism Test

As is discussed in section 6.1, three potential mechanisms through which Brexit impacts corporate TFP have been established, i.e., trade, FDI inflow, and inward migration. Thus, the following equations are constructed to conduct the mechanism tests. Specifically, equations (38), (40), and (42) include three interaction terms $Brexit_{it} \times Trade_{it}$, $Brexit_{it} \times FDI_{it}$, and $Brexit_{it} \times M_{it}$ that examine the effectiveness of these potential mechanisms in correlations between Brexit and corporate TFP in Wales. Here, $Brexit_{it}$ represents the core independent variable, i.e., the interaction term $U_i \times Post_t$ as shown in equation (27), indicating the extent of being impacted by Brexit. More specifically, for instance, equation (37) is constructed by taking the Brexit indicator and total trade volumes as explanatory variables and corporate TFP as the explained variable. Equation (38) then adds the multiplicative term of Brexit indicator and trade as an explanatory variable to equation (37). Thus, if the coefficient ρ_3 is significant, trade can be considered as a moderating effect of Brexit on corporate TFP. The very same logic is applied to other two mechanism tests. Note that in the process of regression analysis, all mechanism variables take log linearised values.

$$CTFP_{it} = \alpha_0 + \alpha_1 Brexit_{it} + \alpha_2 Trade_{it} + \gamma X_{it} + f_i + m_t + \varepsilon_{it}$$
(37)

 $CTFP_{it} = \rho_0 + \rho_1 Brexit_{it} + \rho_2 Trade_{it} + \rho_3 Brexit_{it} \times Trade_{it} + \gamma X_{it} + f_i + m_t + \varepsilon_{it}(38)$

$$CTFP_{it} = \alpha_0 + \alpha_1 Brexit_{it} + \alpha_2 FDI_{it} + \gamma X_{it} + f_i + m_t + \varepsilon_{it}$$
(39)

$$CTFP_{it} = \rho_0 + \rho_1 Brexit_{it} + \rho_2 FDI_{it} + \rho_3 Brexit_{it} \times FDI_{it} + \gamma X_{it} + f_i + m_t + \varepsilon_{it}$$
(40)

$$CTFP_{it} = \alpha_0 + \alpha_1 Brexit_{it} + \alpha_2 M_{it} + \gamma X_{it} + f_i + m_t + \varepsilon_{it}$$
(41)

$$CTFP_{it} = \rho_0 + \rho_1 Brexit_{it} + \rho_2 M_{it} + \rho_3 Brexit_{it} \times M_{it} + \gamma X_{it} + f_i + m_t + \varepsilon_{it}$$
(42)

Columns (1) to (6) in Table 6.5 show the regression results for the moderating effects of trade, FDI inflow, and inward international migration for impacts of Brexit on corporate TFP for firms in Wales. Coefficients of the Brexit indicator and three interaction terms are all significant at the 10% level. Results show that international trade, FDI inflow, and international inward migration in Wales act as mechanisms through which Brexit imposed significant impacts on corporate TFP for firms in Wales. Specifically, since the absolute values of coefficients of all interaction terms are larger than those of the Brexit indicator only, trade, FDI inflow, and inward migration can be considered to strengthen negative impacts of Brexit on corporate TFP

due to negative effects of Brexit on trade, FDI inflow, and inward migration especially from the EU region.

The regular movement of production elements across regions speeds up the development of industrial network features, which, in turn, can boost corporate productivity and strengthen local economic resilience by leveraging business network externalities and synergies (Duan et al., 2022). However, anti-globalisation shocks are estimated to create additional barriers to production factors in international trade, FDI, and labour migration across the world and result in shortage of trade ingredients, innovation, skills, and supply of capital (Goldstein & Gulotty, 2019). The positive impacts of capital, knowledge, and technology resulting from trade, FDI, and migration within corporate management systems contribute to improving corporate productivity, enabling better resilience to shock and fostering economic anticipation. It is important to note that our results provide empirical evidence that Brexit as one of the most important anti-globalisation events might have created significant barriers to improvements in corporate productivity by blocking free movements of production factors, especially between the UK and EU.

Variable	Trade only	Brexit-Trade	FDI only	Brexit-FDI	M only	Brexit-M
	(1)	(2)	(3)	(4)	(5)	(6)
$U_i \times Post_t$	-0.038**	-0.077**	-0.284***	-0.227***	-0.015***	-0.028***
	(4.239)	(2.189)	(2.796)	(3.823)	(3.067)	(0.144)
<i>Trade</i> _{it}	0.029**	0.023**				
	(-0.978)	(-0.002)				
$Brexit_{it} \times Trade_{it}$		-0.295**				
		(2.366)				
<i>FDI_{it}</i>			0.036**	0.033**		
			(2.053)	(3.685)		
$Brexit_{it} \times FDI_{it}$				-0.037*		
				(-0.978)		
M_{it}					0.027**	0.023**
					(3.516)	(1.154)
$Brexit_{it} \times M_{it}$						-0.111***
						(-1.123)
Constant	1.692**	1.248**	1.277***	1.037***	1.145***	1.095***
	(2.659)	(-0.914)	(-1.313)	(2.062)	(1.653)	(-2.714)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 6.5 Mechanism test results

Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	986.976	986.976	986.976	986.976	986.976	986.976
R-squared	0.345	0.377	0.498	0.505	0.589	0.300

Note: ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively. Coefficients of firm and region control variables are emitted.

6.4.5 Robustness Tests

Table 6.6 presents the results of a series of robustness tests, including changing the calculation method of corporate TFP, moving outliers, and changing the sample period. First, corporate TFP is now calculated as the residual from the following production function in the form of equation (43) developed by Gordon (2017), which was initially used in the US.

$$\ln(Y_{it}) = 0.7 \ln(L_{it}) + 0.3 \ln(K_{it})$$
(43)

where Y_{it} denotes the total value-added for firm *i* in year *t*, *L* represents the labour input measured by the total labour costs and *K* means the total capital input measured by total fixed assets. Data of these variables comes from the FAME database and the Company House dataset. Results of the first mechanism test are shown in column (1). Second, the top and bottom 1% of the sample, in terms of corporate TFP, is shrunk to correct for outliers, with the results shown in column (2). Finally, the author uses the new sample period of 2014-2018 and changes the sample size with results shown in column (3). Results show that for all robustness tests, coefficients of the Brexit indicator (Brexit interaction term) are still significantly negative, justifying the robustness of our empirical results.

Variable	CTFP calculation	Outliers	Period change
	(1)	(2)	(3)
$U_i \times Post_t$	-0.233***	-0.426***	-0.501***
	(3.508)	(4.152)	(0.494)
Constant	0.105***	0.127***	0.123***
	(-5.803)	(1.653)	(1.582)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Observations	986,976	725,558	758,901
R-squared	0.345	0.367	0.303

Table 6.6 Robustness test results

Note: ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively. Coefficients of firm and region control variables are emitted.

6.5 Conclusion and Policy Implications

Brexit and its relevant economic uncertainty are believed to have resulted in fluctuations in business environments, local economic growth, and more importantly, corporate productivity in the UK since the 2016 Referendum made the historic decision. Debates on how firms in the UK responded to Brexit have continued for years while relevant studies based on firm-level data are unexpectedly scarce. Furthermore, such debates are very likely to be politicalised in accordance with partisanship and conflicts between the left wing and right wing amid such an era of uncertainty and politicalisation (Gamble, 2021). Utilising 2013-2019 data for 123,372 firms in all 22 local councils of Wales, this study analyses how Brexit (defined by the 2016 Brexit Referendum) affects corporate TFP in Wales. Mechanism tests, heterogeneity tests, and robustness checks are also applied. Based on empirical results, the following conclusions can be drawn. First, the panel data analysis shows that in general, Brexit can significantly hinder growth of corporate TFP in Wales, which is supported by a series of robustness tests. Second, spatial heterogeneity analysis reveals that negative impacts of Brexit on corporate TFP are more significant for firms in South Wales where the number of firms are remarkably more than in other regions and business connections with the EU region are also more frequent. Then, the firm heterogeneity analysis reveals that firms with closer business ties with the EU region are exposed to more significant shock due to Brexit with regard to corporate productivity. Third, trade, FDI inflow, and inward migration are three mechanisms through which Brexit impacts corporate TFP for firms in Wales by lowering the increase rates of all three variables.

These findings raise several policy implications on improvements of economic resilience and business environments in Wales to reduce negative impacts of Brexit on corporate productivity. First, policy makers ought to focus on empirical evidence of potential impacts of Brexit on firms and have a comprehensive estimation of such impacts by also considering its long-term effects and other shocks such as the Covid-19 pandemic and geopolitical conflicts. Several polices can be implemented to enhance the resilience and recovery of corporate productivity in Wales, such as targeted tax cut and subsidies, innovation grants, more investments in skills training projects, expansion of domestic funding programmes, and reduction of trade-related paperwork for SMEs especially with close economic ties with EU countries. These policies are expected to greatly reduce barriers to free trade, FDI inflow, and skilled migration in Wales.

Second, since results of spatial heterogeneity tests show that firms in South Wales are more likely to be impacted by Brexit-driven uncertainty, policy makers in Wales should focus more on corporate performance, financial status, and business resilience for firms in this area and provide additional assistance. Meanwhile, policy makers should also make efforts to optimise the industrial structure in Wales and introduce policies to attract international, especially non-EU investors to de-risk from negative impacts of unstable economic relationship between the UK and EU. It is also important to note that the Welsh government has conducted multiple strategies to attract non-EU FDI and promote international trade, such as introducing plants owned by Hitachi and semi-conductor factories from Taiwan (Munday et al., 2024). These attempts are believed to bring in new resources of labour and capital, leading to higher-level economic competitiveness and corporate productivity in Wales.

Chapter 7 Conclusion and Further Development

Brexit has reshaped Welsh economic landscape by disrupting traditional EU ties, forcing firms to adapt to new trade and investment realities, and exacerbating regional economic disparities. While some adjustments are happening, the long-term economic gains promised by Brexit remain uncertain, particularly for Wales's lagging regions. More specifically, (1) The 2016 Referendum had a much more immediate and significant economic impact than the actual Brexit execution in 2021. This suggests that uncertainty alone—before any policy changes took effect—was enough to disrupt investment decisions, migration flows, and business confidence in Wales. (2) The greatest economic disruptions were concentrated in trade, FDI, and corporate productivity, three key drivers of regional economic growth. (3) The negative impacts were not uniform. Firms and workers with strong EU ties suffered the most, while some non-EU businesses and migrants gained relative advantages, shifting the composition of economic activity in Wales.

In summary, this thesis aims to investigate: 1) how Brexit has impacted and will continue having impact on international migration to Wales, as well as similarities and differences of impacts of Brexit imposed on labour migrants with different demographic patterns (i.e., countries of birth and income levels) in Wales; 2) to what extent has Brexit affected the Welsh

economy measured by GDP per capita, trade, and FDI; 3) how corporate productivity responds to Brexit-related economic uncertainty. To comprehensively validate the analysis on economic impacts of Brexit in Wales, it adopts two key time points of Brexit, i.e., the 2016 Referendum which decided Brexit and the 2021 official execution of Brexit, both of which have set up fundamental context of Brexit for all empirical studies in this thesis. It is important to include these two time points since numerous studies have revealed that Brexit already impacted inward migration to the UK and the UK economy as early as in 2016 instead of 2021 since economic uncertainty driven by Brexit started from the 2016 Referendum, and migrants and firms can get used to the "new normal" of Brexit from 2016 to 2021.

7.1 Review and Forecast of Impacts of Brexit on Inward Migration to Wales

Migrants have been a significant component of the Welsh society, who contribute to economic growth in Wales, thus potential impacts of Brexit on inward migration to Wales might lead to fluctuations in migration patterns and therefore hinder regional economic growth. Additionally, the Welsh economy has been supported by close economic ties with the EU region and frequent labour exchange with EU countries while Brexit-related restrictions on international migration are believed to mostly target for EU migrants to the UK, potentially amplifying negative impacts of Brexit on EU migration to Wales. Thus, the first empirical chapter tries to examine how Brexit has affected migration patterns for EU and non-EU migrants to Wales and whether such impacts will continue amid two additional shocks, i.e., the Covid-19 pandemic and the Ukrainian War from 2023 to 2027.

Brexit has been shown to have significant negative effects on certain groups of migrants in Wales, with these impacts expected to continue for the next five years. Specifically, Brexit has an overall negative impact on EU migrants, while non-EU migrants in Wales remain largely unaffected. Among EU migrants, those earning less than £30,000 annually in the construction and manufacturing sectors are the most adversely affected. Conversely, non-EU migrants appear to benefit from Brexit-related restrictions on international migration, particularly from the EU to the UK, by leveraging their higher-than-average skills and education. This study examines how migrants with different income levels respond to the Brexit shock by analysing data based on income thresholds. The mechanism test reveals that there are two potential channels through which Brexit specifically has negative impacts on EU migrants to Wales, i.e., Wales-EU trade and the number of EU-related firms in Wales, since growth rates of both channels are estimated to be reduced due to Brexit.

7.2 Validation of Impacts of Brexit on the Welsh Economy

The Welsh economy is an important component of the UK economy, and close economic connections between Wales and the EU region indicate that the Welsh economy might face more significant impact due to Brexit than other regions of the UK. Meanwhile, since the level of economic growth in Wales is lagging behind the UK average, analysis on impacts of Brexit on the Welsh economy could encourage similar research on economic impacts of Brexit in lagging regions in the UK and how these regions can catch up with the national average in terms of economic growth. This chapter adopts two critical time points, 2016 Q2 when the 2016 Referendum was held and 2021 Q1 when the transition period ended, to examine how the Welsh economy (measured by GDP per capita, trade volumes, and inward FDI) responded to Brexit. Major findings include:

(1) Trade. It is found that the 2016 Referendum in Q2 2016 significantly impacted the import and export dynamics of Wales. It notably increased the influx of goods from non-EU trading partners to Wales while discouraging exports from Wales to both EU and non-EU countries. However, the implementation of Brexit in Q1 2021 appears to have had minimal influence on Wales's trade dynamics. Our observations suggest that factors previously identified in studies, such as the clarification of Brexit-related trade policies and the completion of free trade negotiations between the UK and the EU may explain why the effects of Brexit on trade between Wales and its partners have lessened in significance since 2021.

(2) Inward FDI. In general, the negative impacts of the 2016 Referendum on the growth of inward FDI in Wales are more significant than those of the official Brexit agreements in 2021. Our analysis indicates that the GDP growth rate in Wales, the GBP-USD exchange rate, the inflation rate in the UK, and the country risk index significantly influenced FDI inflows in Wales during the sample period from 2011 to 2022.

(3) GDP per capita. It is also observed that the 2016 Referendum lowered the real GDP per capita in Wales compared to an ideal Doppelganger Wales (which is based on real data of economically similar French and German regions) that did not experience the referendum. The gaps in GDP per capita between real Wales and Doppelganger Wales began to narrow in 2021, indicating the diminishing marginal impacts of Brexit on economic growth in Wales.

7.3 Revisit Brexit: Firm-Level Impacts in Wales

The Welsh economy is majorly supported by firms, especially SMEs, thus how firms respond to Brexit with regard to their productivity deserves more attention. This chapter adopts both panel data model with FE method and a comparative PSM-DID analysis on firms in Wales and Bretagne, France, two extremely similar regions in terms of economic growth, industrial structure, and business environment.

Based on empirical results, the following conclusions can be drawn:

(1) The panel data analysis indicates that Brexit significantly hinders the growth of corporate total factor productivity (TFP) in Wales, a finding supported by a series of robustness tests.

(2) Spatial heterogeneity analysis reveals that the negative impacts of Brexit on corporate TFP are more pronounced for firms in South Wales, where there are significantly more firms and more frequent business connections with the EU region.

(3) Firm heterogeneity analysis shows that firms with closer business ties to the EU are more significantly affected by Brexit in terms of corporate productivity.

(4) Trade, FDI inflows, and inward migration are the three mechanisms through which Brexit impacts corporate TFP for firms in Wales, by reducing the growth rates of all three variables.

7.4 Restrictions and Future Development

Empirical studies in this thesis are not without limitations. First, the data availability restricted the comprehensiveness of analysis on economic impacts of Brexit in Wales, especially with regard to impacts of Brexit on trade, migration, and corporate performance in Wales, and gives a short time frame of sample analysis, limiting the ability to fully capture long-term effects and trends. Second, decomposing effects of other shocks, namely the pandemic and global trade tensions, and validation of causal effects of Brexit can be very complicated, and this thesis only justifies that the pandemic did not amplify impacts of Brexit on inward migration to Wales. Third, several external factors have not been considered in this thesis, such as de-risk campaign of trade with China and conflicts in the middle east, while these factors might lead to long-term structural changes to the economy. Last but not least, Brexit as a political agenda might face fluctuations in the future, and the possibility of restructuring close economic relations between the UK and EU could be very high if Labour Party wins the 2024 general election.

As such, future developments of this thesis will include the following aspects. First, given that Brexit is perceived to have long-term impacts on inward migration to the UK and the UK economy, future studies to capture such impacts on inward migration to Wales and the Welsh economy are required, which can help identify trends and effects that emerge over time, beyond the initial transition period and amid changing landscape of regional and global economies. It is extremely important to insert analysis on this topic into a global context since the pandemic and geopolitical conflicts are believed to have extended impacts on global economy including the UK and Welsh economies (Gupta et al., 2023). Second, it is aimed to have closer collaboration with local governments and agencies in Wales to have access to better-quality data with a wider range of period and higher accuracy, especially for individual-level inward migration and firm-level business performance. Third, on the basis of individual and firm-level data, behavioural economic analysis can help to understand how businesses and migrants adjust their behaviours in response to Brexit, which requires corporate surveys and individual interviews. There are already relevant studies available, such as Fakhry (2019) who claims that Brexit leads to a limited change in behavioural factors of the UK financial market, and Edward and Fayoumi (2022) who reveal that business strategies for a number of firms in the UK are fluctuated by Brexit-related business uncertainty. Last but not least, one of the most important targets of Brexit is to regain economic sovereignty and growth in the UK especially in leftbehind regions, and numerous studies have shown the correlation between voting for Brexit and being economically left behind (Watson, 2018; Nurse & Sykes, 2019). However, it remains doubtful whether economic growth actually recovers after Brexit in these areas since few studies have conducted to quantitatively analyse how economic growth responds to Brexit in left-behind regions of the UK. Wales has a number of left-behind or lagging regions in the UK with extremely lower GDP per capita compared to the national average. Thus, analysing the correlation between voting behaviours in the 2016 Referendum and economic growth since 2016 in lagging areas in Wales should be another key development in the future. Such analysis can bring insight into estimating the difference between expected and real economic outcomes of similar isolationism and independence events around the world and provide policy implications for governments.

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Appendices

A) Calibration of Corporate TFP Using Primal and Dual Measures

To further provide calibration of corporate TFP for firms in Wales, both primal and dual measures of corporate TFP are applied in this section, and the derivation of this process is shown below, based on Hsieh (2002).

Assume the Welsh economy is a small open economy with a perfectly competitive market. The sector *s*'s output at time *t*, i.e., Y_{st} , should be equal to the payment to the sector of production, say capital and labour for the purpose of illustration as shown below in Equation (44):

$$Y_{st} = r_{st}K_{st} + w_{st}L_{st} \tag{44}$$

where K_{st} and L_{st} represent the capital stock and labour employment, respectively, and r_{st} and w_{st} are the rental price of capital and the wage.

Take the total derivative of the equation above with respect to time and divide it by Y_{st} :

$$\frac{dY_{st}}{Y_{st}} = \frac{K_{st}dr_{st}}{Y_{st}} + \frac{dK_{st}r_{st}}{Y_{st}} + \frac{L_{st}dw_{st}}{Y_{st}} + \frac{dL_{st}w_{st}}{Y_{st}}$$
(45)

Change the previous equation by making the labour share and the capital share appear, we can get:

$$\frac{dY_{st}}{Y_{st}} = \frac{K_{st}r_{st}}{Y_{st}}\frac{dr_{st}}{r_{st}} + \frac{K_{st}r_{st}}{Y_{st}}\frac{dK_{st}}{K_{st}} + \frac{L_{st}w_{st}}{Y_{st}}\frac{dw_{st}}{w_{st}} + \frac{L_{st}w_{st}}{Y_{st}}\frac{dL_{st}}{L_{st}}$$
(46)

Let s_{st}^{K} denote the share of capital for each firm s_{st}^{L} denote the labour share. By definition, we have $s_{st}^{K} = \frac{K_{st}r_{st}}{Y_{st}}$ and $s_{st}^{L} = \frac{L_{st}w_{st}}{Y_{st}}$, and it is easy to know that $\frac{dx}{x}$ means the growth rate of variable x, denoted as \hat{x} .

Then, the previous equation can be written as follows after rearrangement of terms:

$$\widehat{Y}_{st} - s_{st}^K \widehat{K}_{st} - s_{st}^L \widehat{L}_{st} = s_{st}^K \widehat{r}_{st} + s_{st}^L \widehat{w}_{st}$$

$$\tag{47}$$

where the left-hand side represents the primal measure of corporate TFP, and the right-hand side is the dual measure of corporate TFP. The derivation only depends on one single assumption of market competitiveness without any other assumption such as the form of the production function.

Assume that the production function takes the Cobb-Douglas form, i.e., $Y_{st} = A_{st}K_{st}^{\alpha}L_{st}^{1-\alpha}$, then $s^{K} = \alpha$ and $s^{L} = 1 - \alpha$. It is very straightforward to extend the dual measure to more than two input factors, i.e., $\hat{A}_{st}^{D} = \sum_{j=1}^{n} s_{st}^{j} \hat{r}_{st}^{j}$, where \hat{r}_{st}^{j} is the growth rate of price of input *j* and s_{st}^{j} is its share. It should be noticed that the theoretical equivalence between the primal measure and also holds for more general CES production function.

Here are sample steps to calculate the dual measure of corporate TFP in Wales based on FAME data:

- Compensation of labour or total costs of labour input: *Comp_L* (directly observed).
- Labour input: *L* (directly observed).
- Labour share: $s_L = \frac{Comp_L}{Y}$
- Nominal Wage: $w^n = \frac{Comp_L}{L}$.
- Real wage growth: $\widehat{w} = \widehat{w}^n \pi$, where π represents GDP-deflator inflation.
- Compensation of capital measured by total fixed assets: $Comp_K$ (directly observed).
- Capital share: $s_K = \frac{Comp_K}{v}$.
- Nominal capital rental price: r^n from FAME data, and
- Real capital rental price: $\hat{r} = \hat{r}^n \pi$.

Based on rules above, after rounds of calibration using the FAME data, Annual Business Survey data, and Labour Force Survey data for firms in Wales during the sample period, 2013-2019, the author finds that the typical shares of capital and labour in the Cobb-Douglas production function for the case of firms in Wales are 0.723 and 0.277, respectively, which is

slightly different from the US level, i.e., 0.7 and 0.3. The same regression analysis using the benchmark model is performed and it is also found that Brexit significantly discourages further increases in corporate TFP for firms in Wales in 2013-2019.

B) PSM-DID Analysis: Methodology and Results

Wales and Brittany in France not only share the same linguistic and historical root but also have very similar levels of economic growth, business environments, and industrial structures. According to data from ONS in the UK and INSEE in France, differences in GDP per capita, FDI inflow, inflation rates, proportions of sectors, the number of total firms, and income levels between Wales and Brittany are extremely similar during the sample period. It provides a solid foundation for comparative analysis based on the DID methodology since firms in Wales were directly impacted by Brexit while firms in Brittany did not receive direct Brexit shocks. It is also important to note that totally having the same features for firms in these two regions is impossible, and initial differences in local economic growth and corporate performance between these two regions might lead to significant sample bias that reduces the robustness of DID analysis. Thus, the propensity score matching (PSM) method is applied.

The propensity score matching (PSM) is a frequently employed quasi-experimental technique enabling interventional effect analysis using non-experimental or observational data (Rosenbaum & Rubin, 1983). This method transforms raw data into synthesized data that adheres to the fundamental assumption of parallel trends inherent in the DID approach, achieved by matching each treated unit with a non-treated unit possessing similar characteristics. The decision to utilize the PSM-DID method is motivated by the following considerations. First, Brexit as a policy shock presents an economic quasi-natural experiment since firms in Wales and Brittany have no influence on the result of Brexit, and firms in the UK were directly involved while those in France were not regulated by UK policies. Second, removing the self-selection bias entirely with the DID estimation strategy proves challenging due to the significant heterogeneity in corporate performance among firms in different cities. The PSM method can effectively reduce such bias by smoothening the spatial and corporate heterogeneity.

Specifically, the implementation of the PSM method in this study includes the following steps. First, it is essential to select several covariates such as GDP per capita and the population density to define the similarity between city individuals. A logit model of binary choice was established to estimate the similarity. Second, linearised propensity scores are calculated to define similarity between different cities to ensure the consistency between propensity score similarity and covariate similarity. Finally, results of the PSM process can provide the effectiveness of the matching, shown in Figure 3. Results show that distributions of propensity scores for corporate TFP for firms in both Wales and Brittany show the format of normal distribution after the PSM process, indicating that self-selection bias has been reduced to a minimum.



Figure A Bar chart of propensity scores

Notes: The propensity score signifies the likelihood that each firm in Wales or Brittany will be impacted by Brexit, specifically the probability of being assigned to the treatment group. The vertical axis represents the density of propensity scores. "On support" indicates successful matching of samples using the PSM method, wherein both treatment and control group propensity scores fall within the common support range. Conversely, "off support" signifies unsuccessful matching after employing the PSM method, suggesting that data from these samples should be excluded.

Specifically, the implementation of the PSM method in this study includes the following steps. First, it is essential to select several covariates such as GDP per capita and the population density to define the similarity between city individuals. A logit model of binary choice was established to estimate the similarity. Second, linearised propensity scores are calculated to define similarity between different cities to ensure the consistency between propensity score similarity and covariate similarity. Finally, results of the PSM process can provide the effectiveness of the matching, shown in Figure 3. Results show that distributions of propensity scores for corporate TFP for firms in both Wales and Brittany show the format of normal distribution after the PSM process, indicating that self-selection bias has been reduced to a minimum.

Columns (1) to (4) in Table 7 show results of PSM-DID analysis without firm and region FE, with region FE only, with firm FE only, and with both firm and region FE, respectively. Time FE applies in all columns since it is embedded in the benchmark DID model. It can be found that the comparative analysis also reveals significantly negative correlations between Brexit uncertainty and corporate TFP, and firms in Wales would have suffered more from negative impacts of Brexit on corporate productivity than those in its French counterpart. It is critical to highlight potential long-term impacts of Brexit uncertainty on corporate productivity in the UK, including Wales, by comparing corporate TFP with firms in France and Germany while these firms were not directly affected by Brexit and benefit from the EU free market and EU free trade agreements with non-EU countries, especially Japan and China.

Dependent Variable	CTFP				
	(1)	(2)	(3)	(4)	
$U_i \times Post_t$	-0.119***	-0.231***	-0.197***	-0.204***	
	(0.025)	(1.238)	(0.012)	(2.378)	
lnGDP		0.205**		0.236***	
		(4.678)		(2.317)	
UR		-0.012		-0.015	
		(1.582)		(0.578)	
IR		0.005		0.003	
		(0.006)		(1.588)	
lnFDI		0.065**		0.043**	
		(-1.631)		(-1.582)	
lnTrade		0.108**		0.129**	
		(-0.067)		(0.482)	
lnRevenue			0.339**	0.356**	
			(-1.346)	(3.287)	
ROA			0.278***	0.264**	
			(1.059)	(0.095)	
NPM			0.004**	0.006**	
			(2.791)	(1.218)	
lnN			0.082	0.045	
			(2.556)	(-0.369)	
COR			0.032**	0.025**	
			(0.008)	(-1.729)	

Table A PSM-DID regression results

DAR			-0.002**	-0.001**
			(-1.446)	(2.083)
lnLife			0.012*	0.005**
			(3.958)	(-0.006)
Constant	1.032**	0.989**	1.005***	0.893***
	(0.996)	(1.205)	(-0.327)	(2.225)
Year FE	Yes	Yes	Yes	Yes
Firm FE	No	No	Yes	Yes
Region FE	No	Yes	No	Yes
Observations	1,832,043	1,832,043	1,832,043	1,832,043
R-squared	0.217	0.494	0.389	0.625

Note: ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.