University of Economics-Varna

Faculty "Management"
Department of International Economic Relations

Gergana Kamenova Kaloyanova

Impact of Brexit on the supply chains in Great Britain

Abstract

dissertation for the Ph.D. program in World Economy and International Economic Relations

Varna, 2025

The dissertation consists of an introduction, three chapters and a conclusion, a list of references and appendices. It comprises 170 pages, of which 142 pages of main text and 28 pages of list of sources used and appendices. The exposition contains 14 figures and 40 tables. A total of 207 sources from Bulgarian and foreign authors are used. The appendices contain a questionnaire for an empirical study and 21 data tables.

The author of the dissertation is a regular PhD student at the Department of International Economic Relations at the University of Economics - Varna. The dissertation has been discussed by the Department of International Economic Relations.

The defense of the dissertation will take place on XX.XX.2025 at XX o'clock, in Hall XXX of the University of Economics-Varna at a meeting of the Scientific Jury appointed by RD XX/XX of XX.XX.2025 of the Rector of the University of Economics-Varna.

The defense materials are available to those interested on the website of the University of Economics-Varna, www. ue-varna.bg.

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Supervisor:
Prof. Dr. Vesselina Vasileva Dimitrova

Scientific Jury:

1. ....
2. ....
3. ...
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5. ....

Reserve members:

1. .....
2. ....

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1. ....
2. .....

Varna
2025

The dissertation has been discussed and approved for public defense by an extended staff of the Department of International Economic Relations at the University of Economics-Varna according to the RD XX/XX of XX.XX.2025 of the Rector of the University of Economics-Varna.

Author: Gergana Kamenova Kaloyanova
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I. General characteristics of the dissertation

The theory and practice of supply chains is becoming an increasingly relevant and significant topic in academic and business circles around the world. This is a consequence of significant changes in the global economy brought about by geopolitical, economic and health crises. Supply chain management has become one of the main objectives of businesses to achieve stability, profitability, competitiveness and sustainable development in an increasingly dynamic and uncertain world.

World politics has been moving for many years in the direction of globalisation, which has allowed a significant reduction in production time, a drastic reduction in costs, a reduction in inventories, but one particular event has shaken Europe - the decision of the UK to leave the European Union. Britain became the first member state of the union to decide to leave and pursue an independent economic and trade policy, unbound by EU laws and directives. This brings new, previously unknown challenges for UK businesses and requires significant structural changes in the supply chains, which are under enormous pressure.

The relevance of the thesis topic is justified by the need for a more comprehensive study focusing on supply chains in the UK impacted by the Brexit event. The world has faced a trend opposite to globalisation and it is important to learn from the experience of Britai because it is possible that this trend will continue in the future if other countries decide to follow the UK example and withdraw from the European Union. The experience gained and lessons learned in the early years after Brexit provide valuable formal, statistical and expert information for developing more effective supply chain management strategies when experiencing significant regulatory change.

The urgency of the problem is reinforced by the scale of the enterprises affected. Millions of firms, from small businesses to large corporations, are being forced to rethink and restructure their operational processes to adapt to the new reality of UK-EU trade relations. Companies are regularly looking for new solutions and approaches to reorganise and optimise their supply chains, making this a particularly relevant topic for research and analysis. Understanding the processes outlined above is essential not only for academics but also for practitioners, policy makers and all stakeholders involved in international trade and global logistics. Research on the impact of Brexit on the supply chains in Great Britain is useful for understanding the context of global economic transformation.

The aim of this dissertation is to analyse the impact of Brexit on supply chains in Great Britain. The main *research questions* :

1. Which factors are associated with the UK leaving the EU and how have they affected the supply chains?
2. What are the implications of Brexit for supply chains?
3. Can effective measures be identified in order for businesses to change and to build resilient supply chains?

In order to fulfill the objective and to find answers to the research questions, the following *scientific tasks* are defined:

1. To study the achievements of Bulgarian and foreign authors on supply chain theory;

2. To analyse the Brexit event and the new legislative framework and regulatory changes being introduced and their impact on supply chains;

3. To explore the economic effects of Brexit on supply chains;

4. To analyse the Brexit-related factors and rank them according to their degree of influence;

5. To propose effective recommendations to optimise supply chains and increase their resilience in the new business environment.

Supply chains of organisations in the UK *are the object of study*. The specific factors associated with Brexit that are leading to changes in the processes of UK supply chains *are the subject of study*.

The thesis claims that Brexit has had a significant impact on UK supply chains such as increased operational costs, labour shortages, extended delivery times and complicated administrative procedures. These effects will force business organisations to take steps to adapt and increase the flexibility and resilience of their supply chains in order to maintain their business and competitiveness in international markets.

The research methodology is based on a combination of quantitative and qualitative methods for data collection and analysis, providing a comprehensive approach to the study of the problem. Information was gathered through documentary analysis of official data, agreements and regulatory documents, as well as through survey for supply chain experts in the country.

Fuzzy AHP method, comparative data analysis and content analysis of expert opinions and documents were applied for data analysis.

Limitations of the study relate to the impact of other factors that also have an effect on UK supply chains, such as the Covid-19 pandemic and military action in Ukraine. Including these factors would make it more difficult to define the implications arising from the UK leaving the EU. Examples of other studies that only examine Brexit are those by Dhingra et al. in 2017 or Bailey and De Propris in 2019. *The time frame of the study* covers the period from 2016 to 2025 or the period from the referendum on the UK's membership of the European Union to February 2025. *The territorial scope* is limited to Great Britain. The research in this thesis covers only the country and does not look in detail at the effects on other EU or non-EU countries as the main research interest is focused on changes in domestic UK supply chains.

A specific toolkit was used to conduct the research, creating a structured survey questionnaire for supply chain professionals, as well as documentary analysis and statistical data. For the purposes of the dissertation 207 literature sources of Bulgarian and foreign authors were studied.

The thesis is structured in three chapters. *The conclusion* of the dissertation summarises the findings and recommends adaptation strategies to UK business.

II. Structure and content of the dissertation

Introduction

Chapter One: Theoretical framework, scope and characteristics of supply chains

1.1. Essence, participants and structure of the supply chains

1.2. Scope of strategic supply chain management and suggestions for optimization through just-in-time JIT chains and Lean Six Sigma methodology

1.3 Challenges and risks to supply chains and their management in the context of the 'resilient' supply chain concept

Chapter Two: Challenges to UK trade relations before and after Brexit and impact on supply chains

2.1. Brexit scenarios and their effects on the UK supply chains when leaving the EU

2.2. Changes to UK supply chains, economy and business since formally leaving the EU

2.3. Effects of the UK's new immigration system on supply chains

Chapter Three: Analysing Brexit influencing factors on UK supply chains through fuzzy AHP analysis

3.1. Theoretical foundations and methodology of AHP and fuzzy AHP analysis

3.2. Study steps and analysis of the results

3.3. Possible adaptation strategies for supply chains after Brexit

Conclusion

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Annexes

III. Brief summary of the thesis

Chapter One: Theoretical framework, scope and characteristics of supply chains

In **chapter one, section one**, the author reviews the literature from Bulgarian and foreign authors in relation to supply chain theory and the evolution of the concept of supply chain.

Table 1

Evolution of views on " chains"

Period	Evolution in views
1980-1990	Focus on material flows and logistics
1990-2000	Information flows and relationships between partners in the chain are included
2000-2010 .	Focus shifts to integration and cooperation between partners in the chain
2010-2020	The themes of sustainability, resilience and digitalisation are added
2020-2024	Focus on resilience, circular economy and digital transformation

Source.

Modern definitions of supply chains are more complex and cover a wider range of aspects, including technology, resilience, flexibility and social responsibility. *Factors leading to the need for supply chains to evolve since the 1980s include*: an increasing degree of specialisation of businesses, growing competition, shortening product life cycles, rapid development of information technology, globalisation of business, changes in consumer expectations, changes in the economic situation.

The author makes a comparison based on a literature review of the concepts of "supply chain" and "logistics" in order to be able to highlight the differences between them. Many authors compare supply chains with the concept of logistics and most of them such as Christopher, Mentzer, Lambert, Larson are on the opinion that logistics is the narrower concept than supply chains. Supply chains involve not only the movement of goods and information through a business, but also the coordination of processes tied to all entities in the chain - suppliers, customers and the organization itself (Christopher, 2011). Some authors prefer the term 'supply network', which they argue better reveals the complex structure of linkages and relationships. According to Christopher and Peck (2004) supply chains are a network that is more like a tree with multiple branches and a complex root system with the trunk of the tree representing the processes of the main company.

Each organisation is involved in at least one supply chain. *The participants in* a typical supply chain are the following: raw material suppliers, intermediate product manufacturers, final product manufacturers, wholesalers, retailers, final customers, service providers. The structure and participants in the supply chain may vary depending on the industry, product or service, and the specific business models of the organisations involved. Some supply chains may be simpler but others are extremely complex, with multiple tiers of suppliers and intermediaries.
In every supply chain, there is one lead company that is the basis for considering the chain. The chain itself is analysed from the point of the main organisation . The immediate suppliers and customers of this company are referred to in the literature as 'tier one partners'. The suppliers of the direct suppliers and the customers of the direct customers for the organisation are referred to as 'second tier partners' and so on. Supply chains have in addition to length as a characteristic a width or vertical dimension, which is determined by the number of participants at each level. According to this dimension, they are divided into narrow chains, which have few participants at each level of suppliers and customers, and wide supply chains with many partners at each level of suppliers and customers. According to length, they are divided into short and long supply chains. Supply chains can be characterised by a certain geographical scope, degree of vertical integration, degree of complexity of structure, degree of flexibility. The structure should be such that the supply chain adapt quickly to changes in demand and the surrounding environment (Christopher, 2000).

The structure of supply chains determine the extent to which information and processes in the chains will be visible and traceable. It also determines how long the cycle time for order fulfilment will be. Supply chains are built with varying degrees of digitalisation.

The structure of supply chains determines the degree of resilience and flexibility, what is the environmental and social impact of the chain and its ability to recover from disruptions or crises (Ponomarov and Holcomb, 2009).

The theoretical review allows the author to summarise and propose own definition of "supply chain" for the purpose of this study. The proposal is for a broad definition that best fits the current reality in which supply chains need to be efficient and optimised, but at the same time sufficiently resilient to negative events and sustainable. *The author's* proposed *definition* is:

"A supply chain is a complex system of interrelated and interdependent economic entities, processes and information flows that function in synchrony to transform raw materials into finished products or services while maximising value and enhancing competitiveness. This dynamic network integrates physical, financial and digital resources, adapting to changing market conditions, technological innovation and global challenges to ensure sustainable and efficient satisfaction of consumer demand while optimising costs and minimising environmental footprint, seeking adaptability and resilience over time."

Section two of chapter one focuses on the scope of strategic supply chain management, suggestions for optimization through just-in-time JIT chains and Lean Six Sigma methodology, which are important for the supply chains.

In order to maintain its competitive advantages and maximize its profits, the company needs to coordinate its activities first internally and then with the rest of the supply chain. This leads to the need to coordinate supply chain management activities. Organisations whose supply chains can best meet customer requirements and are better managed have a larger market share than their competitors and are more flexible and resilient to negative events that can disrupt supply chains.

The term *Supply Chain Management* (SCM) originated in the 1980s but became more widespread in the 1990s. The author reviews the definitions of supply chain management found in the academic literature to highlight the importance of supply chain management in the normal execution of processes and especially when a negative event occurs that challenges supply chains in the organisation, such as Britain's exit from the

European Union. Supply chain management is key to any organisation's competitive advantage. Theory and practice agree that in recent decades competition has taken place not between individual organisations but between the supply chains in which they participate.
Modern definitions increasingly include aspects such as sustainability, digital transformation and resilience. In order to properly plan supply chain management activities, the following conditions need to be met: high adaptability, sustainability (implementation of environmental and social standards), digitalisation (use of technologies such as artificial intelligence, blockchain and the Internet of Things), risk management (implementation of strategies to identify, assess and mitigate the impact of risks), collaboration (fostering close cooperation and information exchange between all participants in the supply chain).

The theoretical review allows the author to summarize and propose own *definition of "supply chain management"*, which encompasses the challenges and tasks of supply chain management in the current uncertain environment and reflects the increasing complexity and global nature of modern supply chains. *The author's* proposed *definition* states:

"Supply chain management includes the strategic planning, coordination and optimization of complex and international networks of interrelated activities, processes, resources and organizations. It aims at the effective and efficient movement of material, financial, information flows from the original suppliers of raw materials to the end user while also achieving environmental and social objectives. In the face of global uncertainty, it is necessary to create and maintain a sustainable and adaptable system that brings long-term value to all parties and can survive prolonged and adverse environmental conditions."

The most integrated, interconnected and efficient supply chains are the so-called *just-in-time (JIT) supply chains*, which are widespread in the UK, hence the dissertation examines and highlights their advantages and disadvantages with regard to the occurrence of negative events that can disrupt them. The JIT concept was developed by Toyota Motor Corporation as part of their production system in Japan in the 1950s. The JIT strategy is characterized by minimal inventories, frequent and small deliveries of raw materials, close cooperation with suppliers, rapid response to changes in demand, focus on quality and waste reduction. Raw materials and semi-finished items are delivered at short intervals in small quantities so that they can be immediately put into production.

The advantages are the more efficient use of financial capital and increased flexibility. The biggest advantages of these supply chains are reduced costs and high quality of products and services offered (McCann, 2018). The main disadvantages are vulnerability to supply disruptions and the need for extremely precise planning. Christerher and Peck (2004) draw attention to the efficiency-to-surplus ratio. Extra capacity and inventory is useful for building resilient supply chains. A reserve can be provided to allow dealing with a negative situation or sudden fluctuations in demand. Re-stocking at every stage is not advisable, but there can be selective use of reserves to increase the resilience of supply chains. JIT supply chains are sensitive to an undefined event or crisis. Some of the main challenges relate to customs checks and documentation, increased border crossing times, additional administrative burden and bureaucracy; adaptation to new standards and certifications; planning uncertainty, need for additional warehousing.

To optimize supply chains and eliminate unnecessary activities that do not add value, *Lean Six Sigma methodology* is applied in organizations. It is an integrated process management approach that successfully combines *Lean (focused on reducing waste)* and *Six Sigma (focused on improving quality)* methodologies. This approach can lead to significant improvements in process efficiency and quality in chains. According to the Lean Six Sigma methodology each project consists of five interrelated and sequential phases that it goes through to be improved (DMAIC-The 5 Phases of Lean Six Sigma,). The phases are as follows: the Define phase, the Measure phase, the Analyse phase, the Improve phase, and the Control phase. Lean Six Sigma methodology is used by organizations to optimize various aspects of supply chains. There are challenges in actively using the methodology in companies, but despite these challenges, the benefits achieved make Lean Six Sigma an attractive approach to enhance competitiveness. The methodology reduces weak links and risk, but it is also possible that over-optimization of these chains makes them more vulnerable to shocks (Sheffi and Rice, 2005). The author also discusses *the strategic management of supply chains*, which is a key factor for the success of modern organizations when negative events occur. It enables companies to transform their supply chains into a tool that contributes to the creation of competitive advantage and long-term value (Sweeney et al., 2018). It focuses on planning and executing strategies that integrate supply chains with the firm's overall business strategy. For supply chains to be more agile and to withstand negative conditions, the focus should not be on reducing the costs, but on dealing with the uncertain business environment and challenges (Koyumdyan, 2023).

The third section of chapter one looks at the challenges and risks facing supply chains, supply chain disruptions, and the benefits of resilient and flexible supply chains under uncertainty. Challenges to supply chains such as the UK's exit from the European Union have revealed their vulnerability, the existence of weaknesses in chains, and the level of interconnectedness of the global economy. Figure 1 summarises the current challenges facing supply chains.

Figure 1

Supply chains risks

Source : SAP, 2023

The global economy is highly interconnected, leading to crises transfering from one region to another or globally and affecting supply chains in more areas. Changes in international trade agreements, such as Brexit, are creating barriers and forcing restructuring of established supply chains. Organisations need to monitor global economic trends regularly and be ready to adapt their chains at short notice. One of the major weaknesses in supply chains is over-reliance on a single supplier or a particular geographic region (Tang & Musa, 2011). To reduce this risk, companies can implement supply diversification strategies, such as incorporating alternative suppliers or building reserve capacity and inventories (Christopher & Holweg, 2011).

Skilled labour shortages are significant risk to supply chains. Rapid technological advances are creating new skill requirements that are not always available in the labour market, leading to structural shortages in industries such as manufacturing and logistics. Lack of sufficient skilled employees can lead to production delays, increased production costs, and lower quality (World Economic Forum, 2020). Fluctuations in exchange rates can have a significant impact on the costs and revenues of global companies, especially on those with international supply chains. Currency volatility can lead to increased import costs, reduced profits and uncertainty in long-term financial planning (Bartram & Bodnar, 2012).

Supply chains are made up of interconnected parts and if one part cannot function because of an event, then the whole supply chain is interrupted. *Supply chain disruption* is a significant problem in today's global economy that can have serious consequences for businesses and consumers of products/services. Supply chain disruption as a concept is*"the interruption of the flow of a process related to the production, sales, and delivery of specific goods or services"* (Reyes, 2023). The factors that can lead to supply chain disruption can be divided into two groups: external and internal to the firm. Table 2 systematizes some main types of supply chain shock states.

Table 2

Types of shocks for supply chains

Types of shocks for supply chains	**Features**
Unpredictable catastrophes	These are historically significant events that could not have been foreseen and resulted in trillions of dollars in losses. Examples include extreme terrorism and large-scale cyber attacks on systems.
Predictable catastrophes	The shocks in this category are of a similar magnitude to the above category, but with the difference that they could be predicted relatively accurately and there is a general preparedness to respond. Examples include financial crises and global military conflicts.

Unpredictable interruptions	These are serious and costly events for the companies involved, but are on a smaller scale than catastrophes. Examples include leaks, industrial accidents, product recalls.
Predictable interruptions	Some interruptions may be noticed in advance. Examples include the UK's exit from the European Union.

Source :McKinsey, 2024

Organisations know in advance of some significant external events that are likely to disrupt their supply chains, as Brexit was for UK organisations.

The most important characteristic of supply chains in relation to risks and mitigation of negative impacts is its *resilience (resilient supply chain)*, the ability of the supply chain to recover quickly after a disruption. It is a chain in the process of readiness, response and recovery from disruptions or failures (Kuyumdyan, 2023). The ability of supply chains to be resilient is more important than ever with the level of globalization and connectivity of world economies and markets. Cristopher and Peck (2004) highlight that in today's global business environment, chains are increasingly at risk of disruptions. They propose four principles for building a resilient supply chain: supply chain re-design; collaboration between supply chain partners; supply chain ability to adapt quickly to change; and a risk management culture. These principles need to be applied simultaneously. It is imperative that companies invest in creating resilient supply chains. To succeed in achieving a high level of agility, businesses need to make their processes similar and clear. Interchangeable production parts and personnel give the company a chance to respond quickly to a negative event by reallocating resources where they are most needed at that moment. Technology plays a key role in managing and mitigating supply chain disruption risks. Artificial intelligence (AI) and machine learning are being used to analyse vast amounts of data and anticipate potential disruptions before they happen. Blockchain technology is being applied to increase transparency and traceability in supply chains.

Chapter Two: Challenges to UK trade relations before and after Brexit and impact on supply chains

The first section of chapter two analyses possible Brexit scenarios and their effects on UK supply chains in the event of a Brexit. On 23.06.2016 the UK held a referendum on the country's membership in the European Union and more than half of the voters, 51.89%, indicated that they preferred the country to leave the EU. Immediately following the referendum itself, the potential impact on UK businesses and supply chains of the following scenarios is discussed:

- Brexit without a deal;
- "Hard Brexit" ;
- "Soft Brexit".

A Brexit without a deal would mean Britain leaving without any form of trade agreement with the European Union. The spillover effect is an adverse impact on economic growth rates. This scenario is rather unfavourable if implemented. "*A 'hard' Brexit* means the UK exiting the EU's internal market, or leaving the customs union and the possibility of signing independent trade deals. This unilateral negotiation is time-consuming and would force the UK to follow WTO rules and the 'most favoured nation' clause if it does not conclude the agreement in time. This scenario means equal treatment for all countries and fewer preferences. Leaving the EU customs union means rising prices for finished and intermediate products. Exports to the EU would be subject to customs checks, tariffs and regulatory barriers. Border crossing points will be particularly affected in the coastal region of the city. Dover due to a lack of physical space to store all the goods that need to be processed, and a lack of capacity to manage the new immigration controls. Trade disruption is likely to occur as a result of the new trade barriers. The most serious impacts are expected for automotive manufacturers who rely on complex cross-border supply chains and just-in-time parts delivery. They will be forced to restructure their supply chains.

Estimates are for an increase in revenue for the UK, estimated at around 12 billion, but also for a significant increase in prices, which is likely to be transferred to consumers (UK in changing Europe, 2017). In this scenario, the UK would seek to secure a free trade agreement for goods and services with the EU. The scenario of a *"soft" Brexit* could be considered the most optimal and with the least negative impact. It would closely resemble the UK's relationship with Norway and Switzerland. The Great Britain would remain wholly or largely part of the single market. This scenario would minimise disruption to trade flows and supply chains. The EU would not agree to a partial single market agreement, while the UK would insist on the removal of freedom of movement of people. The scenario that is possible in a 'soft' Brexit is for a new trade agreement that could be broad or specific-limited to certain goods and services (Brodzicki, 2020).

Prior to Brexit, UK supply chains were considered relatively *stable*, but not without challenges. The country benefits from the free movement of goods, services and labour within the European Union, which facilitates trade and logistics. This creates a favourable environment for the development of sophisticated and efficient supply chains that extend across national borders. The UK follows the regulatory framework of the European Union, which ensures harmonisation of standards and rules across sectors. This facilitates cross-border trade and reduces administrative burdens for businesses.

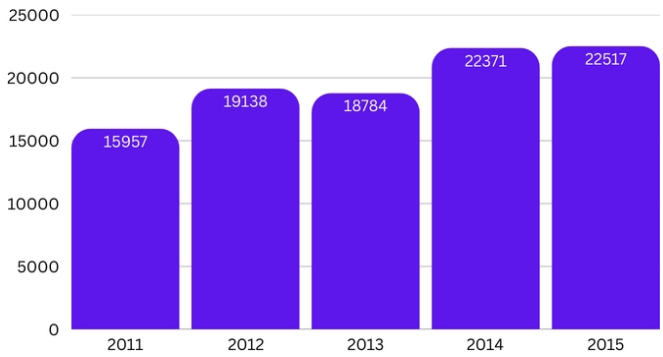
According to a 2018 European Commission report. The UK is among the leading countries in the EU in terms of supply chain integration (European Commission, 2018). The British economy is deeply connected to the rest of the European Union, which contributes to the stability of the supply chains of the companies in the country. The UK's good infrastructure is one of the factors that is significant for good supply chain performance. In terms of commodity prices and pricing in supply chains, Great Britain benefits from the EU customs union, which allows duty-free trade between member states. Thanks to this, the country maintains competitive prices for imported goods and raw materials.

Despite the favourable conditions for optimising supply chains in the UK pre-Brexit, there are also *challenges*. These problem areas have been present since before leaving the European Union. The first challenge is the *reliance on foreign labour in key sectors* - by the year of the referendum to remain in or leave the European Union, around 3.6 million workers, or 11% of the UK workforce, were born abroad (Office for National Statistics, 2016).

According to a 2018 report by the Migration Advisory Committee, sectors such as agriculture, food processing and logistics are particularly dependent on workers from the European Union. Figure 2 reveals the increasing trend in the number of European Union workers prior to the country's exit from the EU.

Figure 2

Number of EU workers in the agricultural sector 2011-2015



Source: data from the UK Parliamentary Commission (2022)

The free movement of people within the European Union has allowed British employers to fill vacancies quickly and easily with EU workers. Dependent sectors would face significant challenges in finding staff, which could lead to costs and potential supply chain disruptions.

Exchange rate stability is also important for maintaining efficient supply chains. Bank of England reports from 2017 and Economics Observatory data analyse the impact of exchange rate changes on supply chains in Great Britain. Figure 3 illustrates these changes for sterling's exchange rate against the euro between 2015 and 2021.

Figure 3

Daily sterling/euro exchange rates for the period 2015-2021.

Source:Economics Observatory, 2021

Research suggests that the significant devaluation of sterling since the Brexit referendum has led to an increase in the cost of imported raw materials and components, putting pressure on many companies' profit margins even before the country's formal exit from the EU. Since Brexit referendum import prices into the country have risen by around 8% and this has been the result of a weaker pound, which has increased costs for companies that depend on imported raw materials, supplies and components. Table 3 summarises some positives and negatives that are important for the state of UK supply chains pre-2016.

Table 3

Benefits and concerns for the state of UK supply chains before referendum (2016).

Benefits	Concerns
Stable access to the EU Single Market	Uncertainty about future trade relations
Integrated logistics systems with the EU	Increase in operating costs
Predictable costs in the chains of	Workforce issues

deliveries	
Efficient customs procedures	Fluctuations in exchange rates
Stable business partnerships	Risk of change in regulations
Good infrastructure	Uncertainty about customs procedures

Source.

Chapter two continues with examples of the effects *of the UK leaving the EU:*

1. *With regard to customs controls and tariffs*

A good example is the port of Dover, which is a critical point for trade links between the UK and the EU. According to data from Imperial College London in 2017, 2 minutes longer at the border for a truck due to customs checks would lengthen the queue of trucks at Dover port by 47 kilometres. Longer inspection times could result in hours of waiting in traffic for drivers, affecting JIT (Just-in-Time) production systems. Congestion can reduce production efficiency, hinder investment and increase transport costs (BBC News, 2018).

2. *Regarding dependence on imports of raw materials*

The main sectors dependent on EU imports are: the food industry, which is importing high amount of agricultural products from the EU; the chemical and pharmaceutical industries, which are highly dependent on european raw materials and intermediate products; transport equipment (including automotive), where 25% of the materials and components come from the EU. A 2016 article highlights the vulnerability of the British *food system* and possible supply chain disruptions in relation to fresh products imported from the European Union (Lang and Schoen, 2016). The UK is dependent on the EU for food as less than 60% of the country's food needs are produced in country . New trade barriers could have as a result an increase in food prices and potentially a reduction in the variety of products available. The food system is generally well adapted to just-in-time systems, so any disruption could be serious. Europe's fresh food products are very important for the Great Britain.

A 2018 study analysed the food industry and highlighted the following risks (Lang and McKee, 2018): rising food prices due to tariffs and the devaluation of the pound; a reduction in the variety of products available due to trade barriers; the risk of shortages of certain products (particularly fresh fruit and vegetables); shortages of agricultural labour; and disruption to supply chains due to customs delays and transport routes. The introduction of border controls would contribute to significant delays in imports of perishable products. This could lead to reduced product shelf life and increased food waste (Askew, 2019). *The pharmaceutical industry* is one of the largest and most important industries in the country and the importance of medical products is critical to the population. A 2016 report by the British Pharmaceutical Industry Association reveals the need to maintain regulatory compliance with the EU to ensure a regular supply of medicines and medical products. According to the report 25% of the world's top 100 prescription drugs are discovered and developed in the UK, and the largest number of biotech products in Europe are developed in the country. The association warns that leaving the European Medicines Agency (EMA) could delay the approval of new drugs for the UK market. It would also hinder access to medical technology, likely increase NHS costs and create a less attractive environment for companies looking to maintain current or make future investments and manufacture products in the UK (Association of the British Pharmaceutical Industry ABPI, 2016). *The automotive industry* is vulnerable to supply chain disruptions in a Brexit situation. From 2010 to 2017, production grew by over 60% and between 2012 and 2017 over £8 was invested in the industry. The automotive sector accounts for around 800,000 jobs in the country. A 2017 study on the impact on the industry and supply chains argued that even small delays at the border would cause significant disruptions to car production, as many components cross the UK-EU border multiple times during the manufacturing process (Bailey and De Propris, 2017). The automotive sector in Europe is highly integrated, with extremely complex supply chains that are dependent on the free movement of individual components within the continent. Research by the London School of Economics indicated that UK car production would fall by 12% and prices would rise by 2.5%.

3. *Regarding regulatory inconsistencies and potential divergence of standards*

Small and medium-sized enterprises (SMEs) in the UK have fewer resources to adapt to the changing business environment as a result of Brexit. A report by the Federation of Small Businesses (FSB) warns that many SMEs are not sufficiently prepared for potential changes in trade relations with the EU. The Federation's research shows that the EU is the largest trading partner for small businesses with 9 out of 10 small exporting businesses trading with the EU (92% of exporters and 85% of importers) with one in five small exporters trading exclusively within the EU single market. The biggest concern relates to the increased administrative burden which would be a real challenge to small businesses trading (UK Parliament, 2020).

4. *In terms of foreign direct investment (FDI) and financial services*, the UK has over £1 trillion worth of FDI with around half of these coming from another EU countries. Part of the UK's appeal to foreign investors is that it provides easy access to the single market. After Brexit, higher trade costs with the EU are likely to decrease foreign direct investment. The UK financial services sector is the largest recipient of FDI and is expected to be negatively affected. Half of the UK's FDI as of 2016 (over £1 trillion) came from the EU and Brexit could potentially reduce inward FDI by around 22% resulting in a 3.4% fall in real income (Dhingra et al.,2017).

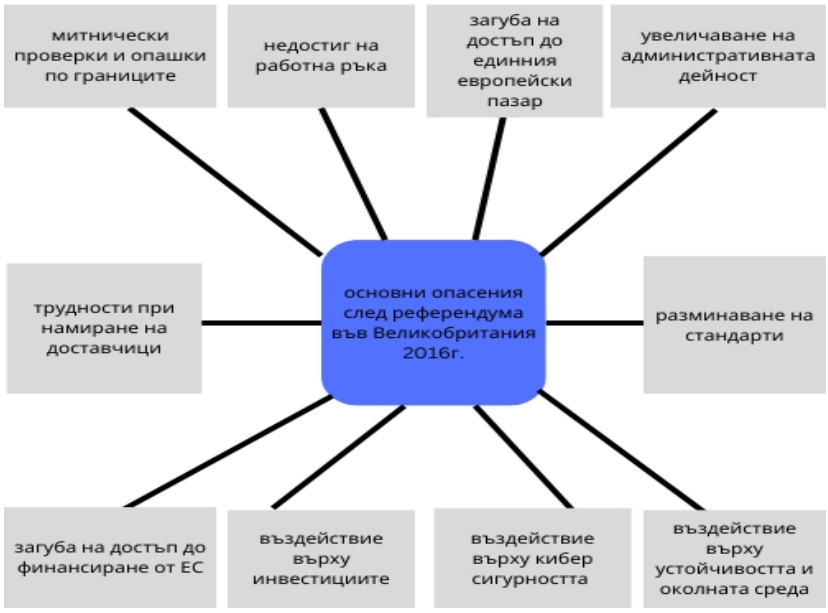
5. *Regarding digital transformation, cyber security, data protection and the environment*

Differences in regulations can result in weaker protection of sensitive data, making supply chains more vulnerable to cyber attacks. There has been an increasing trend of cyber attacks in recent years and although the risk is high, a survey by the UK's National Cyber Security Centre shows that 13% of businesses analyse their direct suppliers and only 7% analyse their entire supplier network. The reasons are unawareness of risk, lack of investment in security, insufficient technology and knowledge (National Cyber Security Centre, 2022). A 2018 study analysed the potential impact of Brexit on environmental policies and sustainable development in the UK noting

potential risks such as: weakening environmental standards, loss of access to EU funding for environmental projects, poor coordination and non-compliance with UK regulations (Burns and Carter, 2018). Figure 4 summarises the potential threats and challenges facing UK supply chains following the 2016 referendum.

Figure 4

Concerns regarding the UK supply chains following the 2016 referendum.



Source: Author

After the referendum from 23.06.2016 in Great Britain there is an announced transition period in trade relations with the EU until 01.02.2020. During this time period, the country remains part of the EU's single market and customs union during the negotiations on the future trading. Nothing changes during this period and the UK continues to abide by all laws and rules but doesn't take part in the decision-making process. The four freedoms remain during the transition period. After the end of the transition, freedoms for UK citizens in EU countries are suspended (European Commission, 2025). On 24 December 2020 the EU and the UK reached an agreement on their future relationship, leading to significant changes for citizens, companies and the public sector in the UK and EU member states. *The Trade and Cooperation Agreement (TCA)* concluded between the EU and the UK sets the framework for the future relationship. It contains special provisions in areas such as trade of goods and services, digital trade, intellectual property, public procurement, air and road transport, energy, fisheries, law enforcement and participation in EU programmes.

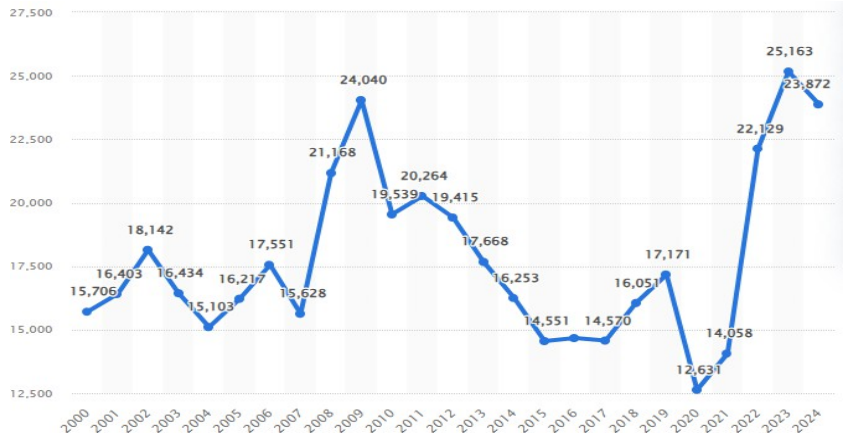
The Trade and Cooperation Agreement goes beyond traditional free trade agreements and provides a framework for maintaining cooperation between the parties.

Section two of chapter two analyses the changes that have occurred in the supply chains, the UK economy and business *since Great Britain formally left the EU*. Britain's exit from the European Union has led *to a fundamental change in trade relations and a reduction in trade volumes.* A study by the Institute for Government Studies in 2023 reveals that despite the Trade and Cooperation Agreement (TCA), the level of economic integration between the UK and the EU is lower compared to the pre-Brexit period. The analysis shows that trade volumes between the UK and the EU are around 7-10% lower than the levels projected if the country had chosen to remain within the European Union (Institute for Government, 2023).

Supply chains in the UK are experiencing significant transformations and challenges following the country's exit from the European Union. Businesses report a negative impact on their supply chains as a result of Brexit. This has resulted in increased costs, delays and the need to restructure logistics operations. Supply chain problems are contributing to inflationary pressures as shortages of goods and increased transport and logistics costs lead to higher prices for consumers. According to the Bank of England, inflation in the UK is also at its highest level in 40 years due to supply chain disruption. Inflation, which reached 10.2% in the first quarter of 2023, is partly due to the combined effect of Brexit, supply chain disruption and other factors. The effects are reduced trade activity, lower levels of business investment and labour shortages in key sectors (Springford, 2023).The UK's exit from the European Union has had a significant impact on the country's business environment, leading to numerous company failures and restructurings (Figure 5)

Figure 5

Number of bankruptcies in the UK between 2000 and 2024



Source: Statista и D.Clark, 2025

Brexit has reduced the productivity of the British economy by between 2% and 5% between 2017 and 2019 (Bloom et al., 2019). The annual decline in the manufacturing sector for the period 2021 to 2022 is about 7%. Continuing problems in the manufacturing sector are associated with slowing growth, a declining share of manufacturing in the economy and deteriorating trade balances. (National Institute of Economic and Social Research, 2023) Despite low domestic productivity, the UK remains the world's fourth largest exporter. The main factor in the success of UK exports is services rather than manufactured goods, for which the country has a significant trade deficit. The UK is the world's second largest exporter of services after the US, but ranks 14th in export of goods, having fallen from sixth place over the past 20 years. Setting the conceptual framework for post-Brexit trade and business relations and following the logic already set out in the thesis statement, specific examples of *post-Brexit* effects are provided:

1. Regarding customs controls and tariffs

New customs procedures, tariffs and non-tariff barriers complicate the administrative process and slow down imports and exports. The introduction of border controls and customs checks is causing delays at borders in the transport of goods between the UK and the EU. This causes disruptions in the supply chain with a particularly negative impact on perishable goods and industries that operate on a just-in-time system. For 2023 the average increase in import and export costs is reported to range between 7.2% and 8.7% (ONS, 2023). According to the Logistics UK (2023) report 65% of UK logistics companies face significant challenges in managing supply chains post-Brexit.

The main difficulties relate to *additional administrative work* and *additional clearance time.* The survey shows an increase in operating costs of 7.5% on average with some companies in the sector experiencing up to 9%. According to Deloitte's 2023 analysis the increase in logistics costs in the post-Brexit period ranges between 8-12% with the main reasons for this cost increase being new customs procedures, additional paperwork and the need to restructure supply chains. Post-Brexit, *port*, *rail* and *aviation infrastructure* is changing significantly to respond to changes in customs clearance. Due to delays at borders and complicated customs procedures, there has been an increased use of rail for freight, particularly at key ports such as Dover. Consolidated net profit for the group, which operates the UK's rail industry, rose by 30% in 2023 and reaches €326 million (Getlink, 2024). Many international companies are switching to rail transport to avoid delays caused by customs checks and to ensure more reliable and predictable deliveries. Driver shortages have also made the use of rail a necessary substitute. Changes are also occurring in the demand for warehouse space- it increased. According to a report by the Office for National Statistics (ONS), the number of UK businesses classified as 'transport and storage' sites was 88% higher in 2021 compared to 2011 and 21% higher compared to 2019.

2. Regarding dependence on imports of raw materials

The food, pharmaceuticals and *automotive* sectors are among the hardest hit by increases in raw material costs in the supply chain. Companies have been forced to rethink their sourcing strategies because of supply chain problems, often seeking alternative suppliers or even bringing some production back to the UK (so called 'reshoring'). *The food industry* is finding itself vulnerable to the new trade barriers of Brexit in terms of commodity prices and availability of certain products. Food and Drink Federation estimates the average increase in operating costs in the food and drink industry to be 6-9% for 2023, with the reason for the increase being additional paperwork and border control delays (FDF, 2023). Exports of food and drink to the EU are down by around 15% in 2023 compared to 2019 and there is a decline in food trade between the UK and the EU

(Food and Drink Federation, 2023). As a result of the changes in food sector, *consumer behaviour is also undergoing significant changes*. Consumers are switching to cheaper alternatives or reducing the frequency of their purchases. British supermarkets suffer from supply disruptions which lead to reduced variety of products and increased prices. Brexit encourages consumers to buy locally produced goods because of disrupted supply chains, but by 2021 the country is not self-sufficient in the short term. It produces only 10% of its fruit and 50% of its vegetables. In 2021 43% of british residents say they are more likely to buy local produce as a result of Brexit (Kantar Worldpanel, 2021). The average increase in consumer prices in the UK over the 2021-2024 period reaches 15-20% with some product categories such as groceries having higher growth. Inflation reaches around 11.1% in October 2022 (ONS, 2023). A study by the London School of Economics in 2023 shows that *food and non-alcoholic beverage inflation* has reached a 45 year peak. The additional costs of the UK's new trade policy with the EU are transfered to the end consumers in the form of higher prices. In *the pharmaceutical sector* there have been price increases for certain medicines. According to the British Generic Manufacturers Association (BGMA), which represents medicine manufacturers, the number of medicines with supply problems reached a two-year peak in september 2023 with 102 medicines in short supply - double the previous record in February 2022 (Forrest, Thomas, 2023). *The automotive sector* is also experiencing serious difficulties. The Society of Motor Manufacturers and Traders states that UK car production has fallen. The automotive sector is increasing prices for consumers. Official figures show an increase in logistics costs, which has an impact on the final prices of car parts, increased administration and time spent at borders (Autovista 24, 2022).

3. Regarding regulatory non-compliance and standards

A British Chambers of Commerce survey of 2 300 SMEs shows that *SMEs are particularly affected* by increased costs for administrative services. 68% of SMEs surveyed revealed that the increase in administrative costs associated with trading with the EU is significant - an average increase of 12-15% on pre-Brexit levels (British Chambers of Commerce, 2023). The Centre for Economic Research at the London School of Economics presents an in-depth analysis of the impact of Brexit on different sizes of businesses- the smaller the size of a UK business, the more affected it is by post-Brexit changes.

4. On foreign direct investment (FDI) and financial services

Investment activity is down by 10-11% compared to forecast levels without Brexit. The result is a slowdown in technological renewal and reduced capital spending in many sectors. FDI has fallen by 37% between 2016 and 2022 as some corporations move operations to the EU to maintain access to the single market (Low and Caswell, 2025). The loss of FDI equates to £29 billion for the UK economy and the value of GDP is reduced by 1.3% due to reduced investment (Haskel, Martin, 2023). Changes are also seen in the service sector, which accounts for around 80% of the British economy. According to Resolution Foundation, service exports have grown by 14% between 2019 and 2023, but Brexit has introduced uncertainty and restrictions to the UK service sectors. The main drivers of services exports are 'other business services' such as consulting, technical, commercial and research services, which have contributed 37% of services export growth in 2008. Smaller but fast-growing sectors include telecommunications, computer and information services, and intellectual property and insurance services. Changes in supply chains are also forcing changes in the UK *financial sector*. Although London remains the largest financial centre in Europe, its share of asset management and international banking operations is declining according to City of London Corporation & HM Treasury, 2023. Post-Brexit, investment from newly established state-owned banks in the UK is only a third of that which the country receives from the European Investment Bank . Between 2009 and 2016, the European Investment Bank invested an average of £6.4 billion a year, reaching £7.5 billion in 2016. In 2022 the UK Infrastructure Bank invests just £2.4 billion.

5. Regarding digital transformation, cyber security, data protection, environment

The free flow of data between the UK and the EU was almost unrestricted before Brexit, but new protection regulations, such as the EU's General Data Protection Regulation (GDPR), introduce additional compliance challenges for UK businesses. The wider digital services and e-commerce sector is affected by Brexit, and the adoption of blockchain technology for tracking shipments is increasing. The UK is testing an automated digital border system to reduce processing times and improve the efficiency of supply chains. The pilot blockchain system can link data and ensure that this data is definitive and not subject to change (University of Surrey, 2022). UK manufacturers are optimising their operations and costs by focusing on protecting of

profit margins and the deployment of artificial intelligence (AI) in supply chains. A significant portion (26%) of them enjoy increased value and greater security, while 24% note cost reductions (Censuswide, 2023). The risks of *cyber-attacks and data exploitation are on the rise* according to a study by the UK's National Cyber Security Centre (NCSC). It shows that 32% of businesses and 24% of NGOs reported breaches or attacks in the last 12 months in the UK with some of these cyber attacks targeting supply chains. The changes to supply chains that are following the UK's exit from the EU also have *environmental implications*. Some organisations are bringing manufacturing back to the UK and this could reduce carbon emissions associated with transporting products long distances. On the other hand, less efficient local supply chains can lead to increased resource use.

The third section of Chapter Two analyses the effects of the UK's new immigration system on supply chains. The European Union is a very good example of unification and integration in the world. It provides the four main freedoms of the European Single Market. These are the free movement of people, capital, goods and services. These freedoms enable goods to move freely within the European Union, citizens to move and reside in a different country within the union, services can be provided across European borders and capital can move freely within the EU. After leaving the European Union on 31.01.2020 the UK has introduced *a new immigration system* which will come into effect from 01.01.2021. This system represents a fundamental change in the country's approach to immigration, applying the same rules to both EU and non-EU citizens.

Labour shortages are a key consequence of Britain's exit from the European Union and are having a serious impact on the country's supply chains. Despite the introduction of the new immigration system and the fact that EU workers can apply for work visas, businesses in the construction, healthcare and tourism sectors are suffering from labour shortages and their supply chains are facing a serious test. The shortage of truck drivers is very serious, leading to delays in deliveries and increased transport costs. According to the Road Haulage Association (RHA) there will be a shortage of around 100,000 truck drivers in the UK in 2021,becoming a serious challenge to the efficient operation of supply chains (Road Haulage Association, 2022). Customers are starting to receive goods late and often are paying a higher price. Most affected are just-in-time (JIT) supply chains, where inventories are minimal and there is a heavy reliance on timely receipt of raw materials and semi-finished items.

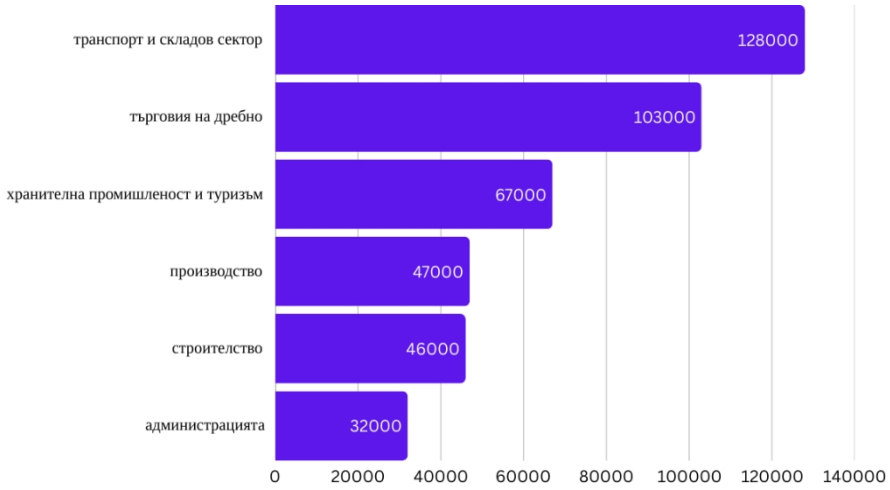
In 2022 a shortfall of 460,000 EU workers in the UK is reported (partly offset by 130,000 jobs filled by non-EU employees). Figure 6 shows net migration to the UK over the period 1991 to 2024 and Figure 7 shows the shortfall in EU workers by sector. After the referendum a decline in EU workers and an increase in non-EU workers began.

Figure 6

The sectors with the most drastic labour shortages are: transport and warehouse management, retail, food , manufacturing, construction and administration.

Figure 7

Missing EU workers by sector, in thousands



Source : Early Impacts of the Post-Brexit Immigration System on the UK labour market Springford, 2023

Lack of staff is a serious problem that can lead to a reduction or stop of the production process or deliveries to the end user. In 2021 an average of one in six (or 17%) people in the UK experienced a shortage of food.

There are three *possible solutions for businesses experiencing staff shortages because of Brexit*: *first*, to recruit more people from outside the EU to fill in vacancies; *second*, through higher wages and training to attract more British workers; *third*, to automate processes where possible and reduce the number of workers needed to carry out processes. Employers in some sectors that relied on EU migrants under free movement, such as warehousing and food and drink manufacturing, are automating more processes. The potential for automation is limited by the cost of investment and the technology available. Low wage jobs that could be automated include positions such as waiters and waitresses, shelf stockers and kitchen helpers. Research shows that in many manufacturing processes and job roles, employers only consider partial automation options (University of Leeds, 2022). The UK is attempting through its policy to encourage the recruitment of non-EU workers to fill in existing vacancies. The arrival of 130,000 non-EU workers to the UK has failed to fully solve the problem, leaving key sectors with many job openings.

Based on the analysis in this Chapter Two, we can summarise that the future of supply chains in the UK will depend on the ability of business, government and academia to work together to create more sustainable, efficient and resilient supply chains. In order to achieve this, investment in infrastructure, education and technology is needed, as well as a flexible approach to regulation and commercial relationships. With the right strategies and collaboration Great Britain has the potential to turn the current challenges of Brexit into an opportunity to build a stronger and more competitive economy. The UK Government knows there is a need for dialogue with business and academia to unite around common guidelines to improve the resilience of UK companies and their supply chains post -Brexit.

Chapter Three: Analysing Brexit influencing factors on UK supply chains through fuzzy AHP analysis

The third chapter analyses the Brexit-related influencing factors that have affected UK supply chains from the perspective of the business itself. The examination of the different sets of factors is in line with the pre- and post-Brexit effects on trade relations examined in Chapter Two of the thesis. For the purpose of the study is used multicriteria analysis - Fuzzy AHP . The use of the Fuzzy AHP methodology allows us to compare the views of supply chain professionals in the UK on the factors of influence related to the country's exit from the European Union. The aim of the analysis is to examine *which Brexit-related factors have the most influence on the supply chains in Great Britain* and make recommendations to improve the country's supply chains and suggest adaptation strategies.

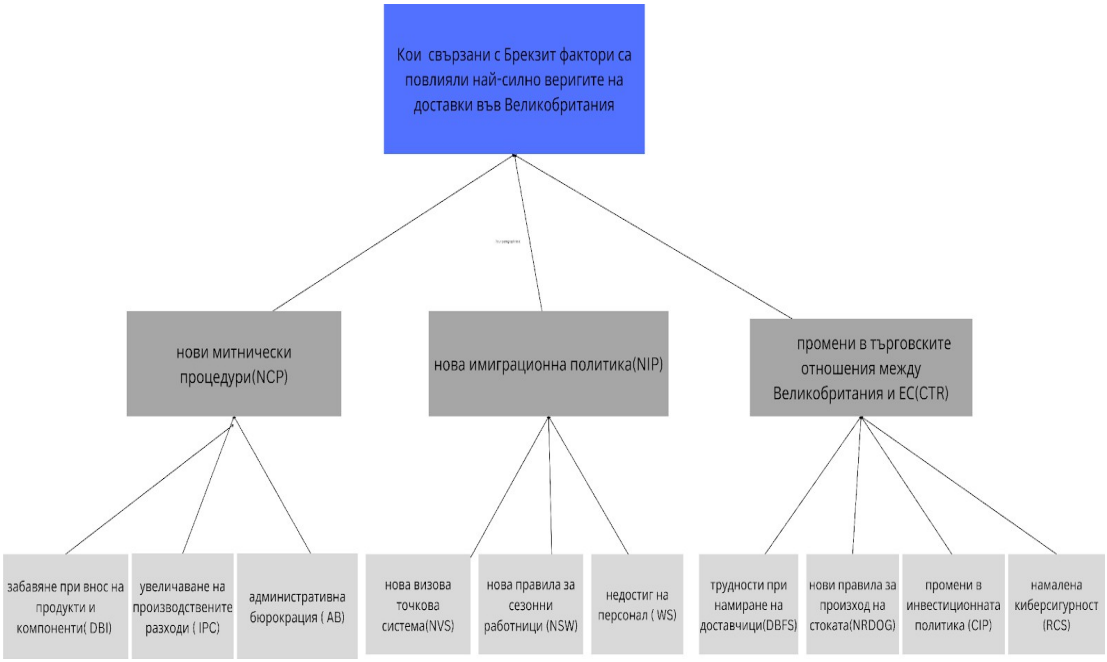
The first section of chapter three discusses the methodology of the Fuzzy AHP analysis, which is a modelled and extended version of the original AHP method. The Fuzzy AHP methodology is a combination of the classical analytic hierarchy process (AHP) and fuzzy set theory for uncertainty modelling (Van Laarhoven and Pedrycz,1983). The integration of the Fuzzy AHP analysis into the study of the impact of Brexit on supply chains represents an appropriate approach. Multicriteria impact analysis allows for the simultaneous consideration of multiple factors affecting supply chains post-Brexit. When weighting factors, it is appropriate to use linguistic scores rather than precise numerical values to express respondents' views.

The second section of chapter three includes the stages of the research and the analysis of the results obtained. For the analysis of the Brexit-related factors that have affected UK supply chains it was necessary to create an 11-question questionnaire. The questionnaire was sent to 18 selected supply chain decision makers working in organisations across the UK. Participating respondents were aged between 27 and 42, 50% over 35. Responses received included 7 respondents in roles such as: "supply chain planning manager", "procurement manager", "logistics operator". The use of small samples in Fuzzy AHP exists in various studies. It is common when the analysis is based on expert opinions.

The questionnaire includes questions related *to the level of expertise and familiarity of respondents* regarding the new customs procedures, the new immigration policy and the new trade agreement after Brexit. The results of the analysis of the responses to the questions :"*How familiar are you with the new customs procedures after Brexit in the UK?", "How familiar are you with the new immigration policy after Brexit in the UK?" , "How familiar are you with the changes to the post-Brexit trade relationship between the UK and the European Union?"* show that respondents are most familiar with the changes to the 2021 TCA between the UK and the EU as a new opportunity to boost the country's exports and benefit from trade preferences. Uncertainty about customs controls and the effects of the immigration remain. Fuzzy AHP analysis is used for the analysis of the next questions in the questionnaire. Figure number 8 provides a visual representation of the hierarchical structure for our particular survey.

Figure 8

Hierarchy of Fuzzy AHP analysis: objective, criteria, subcriteria



Source: Author

The first criterion "new customs procedures" (NCP) has three alternatives:

"Delayed import of products and components" (DBI),

"increase in production costs" (IPC);

"administrative bureaucracy" (AB).

The second criterion "new immigration policy" also has three alternatives:

"new visa points system" (NVS);

"new rules for seasonal workers (NSW)";

"worker's shortage (WS)".

The third criterion "changes in the trade relationship between the UK and the EU" has four alternatives:

"difficulties by finding suppliers" (DBFS);

"new rules of origin of goods" (NRDOG);

" changes in investment policy " (CIP);

"reduced cyber security"(RCS).

The choice of criteria and alternatives is justified in the light of the studies made from official sources and scientific publications analysed in the first and second chapters of the thesis. The selection includes the most significant, recurrent Brexit factors influencing supply chains in Britain. Each respondent compares the criteria and alternatives in pairs, expressing their relative importance in linguistic terms. First, the three criteria ("new customs procedures", "new immigration policy","changes in UK-EU trade relations") in pairs. This section discusses and describes in detail the specific steps and empirical evidence obtained. Tables 4-7 present the summary results for the four hierarchies.

Table 4

Final result for hierarchy 1 - NCP, NIP and CTR

"New Customs Procedures" (NCP)	**"New immigration policy" (NIP)**	**"Changes in the UK-EU trade relationship"(CTR)**
0.3093107	0.3813785	0.3093107

Source: Author

The result shows that respondents believe *that new immigration policy is a more important factor* (0.38) related to Brexit compared to new customs procedures (0.31) and changes in trade relations for UK supply chains (0.31) with the last two scoring equally.

Table 5

Final result for hierarchy 2 - DBI, IPC and AB

Delay in import of products and components (DBI)	**Increased production costs (IPC)**	**Administrative Bureaucracy (AB)**

0.2195094	0.3998040	0.3806866

Source: Author

The results show that *increased production costs (0.40) have the most significant impact on supply chains when new customs procedures are implemented*, followed by administrative bureaucracy(0.38), and lastly, delays in importing products and components (0.22).

Table 6

Final result for hierarchy 3 - NVS, NSW, WS

New Visa Points System (NVS)	**New rules for seasonal workers (NSW)**	**Worker's shortage(WS)**
0.3322000	0.4004594	0.2673406

Source: Author

The results show that *in implementing the new immigration policy, the most significant impact on supply chains is the new rules for seasonal workers (0.40)*, followed by the new visa points system (0.33) and lastly is the shortage of staff (0.27).

Table 7

Final result for hierarchy 4 - DBFS, DBFS, CIP, RCS

Difficulties by finding suppliers (DBFS)	**New Rules of Origin (NRDOG)**	**Changes in the Investment Policy (CIP)**	**Reduced cybersecurity (RCS)**
0.1837810	0.2703636	0.3020315	0.2438240

Source.

The results show that *changes in investment policy matters most to supply chains in connection to the UK-EU trade relations (0.30)*, followed by new rules of origin (0.27),

reduced cybersecurity in supply chains (0.24), and difficulties by finding suppliers (0.18).

The final step in the Fuzzy AHP analysis is to also calculate the "global weights" of the alternatives (Table 8). This step is important in order to obtain an overall ranking of the factors affecting UK supply chains post-Brexit. Calculations are made by multiplying the 'local weight' (under each relevant criterion) by the weight of the criterion. Once the global weights have been calculated, a ranking can be made for the Brexit-related factors which affect most significantly the supply chains in Great Britain. The factor that has the greatest impact ranks highest.

Table 8

Ranking of the Brexit-related factors affecting the UK supply chains post-Brexit

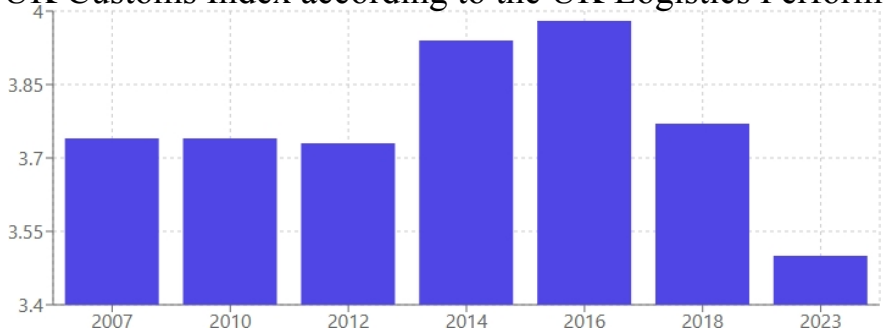
Position	Alternative	Global weight
1	New rules for seasonal workers	0.1527266
2	New visa points system	0.1266939
3	Increase in production costs	0.1236637
4	Administrative bureaucracy	0.1177504
5	workr's shortage	0.1019580
6	Changes in investment policy	0.0934216
7	New rules of origin for goods	0.0836264
8	Reduced cyber security	0.0754174
9	Delay in import of products and components	0.0678966
10	Difficulties by finding suppliers	0.0568454

Source : The Author

Fuzzy AHP analysis shows that respondents believe the Brexit *factor with the most significant impact on UK supply chains is "new rules for seasonal workers*" (0.1527). This highlights the critical role of seasonal workers for businesses and organisations across the UK, with uncertainty in new immigration policy leading to serious challenges for businesses and risks for supply chains post-Brexit. Ranked second among the factors in terms of significance is "new visa points system" (0.1267). This factor adds to the difficulties associated with foreign workers accessing the UK and the limited opportunities to recruit skilled and unskilled staff. "Increasing production costs" (0.1237) and "administrative bureaucracy" (0.1178) are also among the important factors. Their significant ranking shows that new customs procedures and regulations are significantly complicating business operations and processes associated with supply chains within the UK. The Fuzzy AHP analysis clearly shows that *the biggest challenges for UK supply chains post-Brexit are connected to workforce, additional costs and significant administrative burdens.* Companies that adapt their strategies will have a greater chance of resilience and competitiveness in the new economic reality. All the results obtained are in line *with the trends of the UK Logistics Performance Index (LPI) for the period* 2007-2023, for example in relation to the Customs Index presented in Figure 9.

Figure 9

UK Customs Index according to the UK Logistics Performance (LPI) for the period .



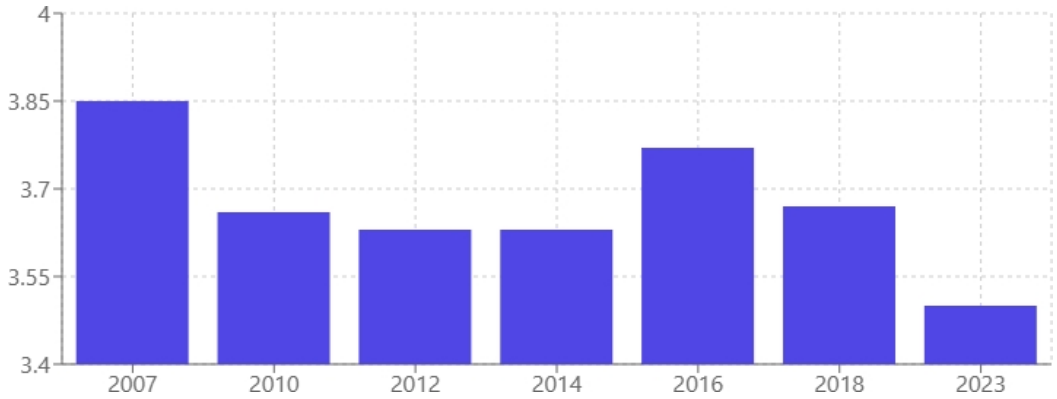
Source: World Bank Report , 2023

Statistics strongly confirm *that post-Brexit UK border customs controls are increasing difficulties for businesses and the supply chain professionals.*

Figure 10 presents more detailed data on the UK ease of shipments index. The index measures the ease and accessibility of arranging international freight shipments. It is key to assessing the efficiency of supply chains and is important in determining total transport costs.

Figure 10

Ease of shipments Index for the UK according to the UK Logistics Performance (LPI) .



Source: World Bank Report , 2023

In 2023 there is a significant drop in the index to 3.5. This data strongly confirms that *customs delays, labour shortages and reduced availability of international shipments following the UK's final exit from the EU are tangible for businesses.*

The third section of chapter three presents possible strategies for adapting supply chains after Brexit. The proposals are fully in line with the analysis carried out in the previous chapters of the thesis and the results of the research conducted using the Fuzzy AHP toolkit:

1. Proposal to develop strategies to address shortages and additional training

Companies can invest in automation and robotics, artificial intelligence and other technologies to reduce the amount of staff needed. An alternative may be to recruit staff from outside the EU who meets the new visa requirements. At the same time, there has been an increase in the number of non-EU nationals wishing to obtain seasonal work visas. Cooperation of government agencies with business organisations to ease recruitment procedures creates opportunities for additional demand for employee training programmes. The Department of Education is allocating 3.8 billion euro to invest in supporting higher and further education, expanding apprenticeship programmes to increase skilled employment opportunities in priority sectors for the country.

2. Proposal to optimise costs and facilitate administrative procedures, including through digital transformation

The adequate solution to minimise the additional bureaucratic burden after Brexit is outsourcing administrative activities to third parties. One of the key advantages of outsourcing to a customs broker is the experience of true professionals who focus on customs activities as a priority (Racounteur, 2021). The average cost of employing an employee in the UK is £3000 and an additional £1530 per year for training. Outsourcing is a good option for UK firms in the face of rising costs, labour shortages and complex regulations. Using digital platforms and blockchain technology to improve traceability and document management reduces risks in logistics, customs and other supply chain procedures. Digital technologies and real-time data analytics can help increase transparency and flexibility in supply chains. Artificial intelligence is used for predictive analytics- forecasting demand, optimising routes and maintaining equipment, reducing costs and increasing efficiency.

3. Supply diversification proposal

A good strategy post-Brexit for companies is to diversify suppliers and not rely on just one supplier. Costs concentrated on just one or two suppliers can make chains easier to manage, but can also increase its vulnerability to a negative event, a crisis.

Encouraging local production and investment in local supply chains will reduce the risks associated with customs regulations. Companies can also seek new trading partners outside the EU to reduce dependence on european suppliers.

4. Proposal to improve cybersecurity

Companies' supply chains need investment in cybersecurity and resilient IT systems to prevent potential attacks and data breaches in supply chains. It is good practice to regularly check the company's own security systems, make an insurance and regularly review the risks associated with suppliers and customers in the supply chain.

5. Proposal to enhance supply chain preparedness to respond to future challenges and crises

Awareness of supply chain risks enables better inventory management, this is an additional reason to develop digital technologies and relationships between partners in supply chains. Supply chain technologies are evolving faster and supply chains are becoming more integrated and connected. These technologies have the ability to quickly extract and analyze data to better understand uncertainty and create inventory models to continue moving goods efficiently and effectively. In the past companies have made strategic changes to their supply chains every 3 to 5 years, but as of today, this is not often enough as continuous changes in the global environment put pressure on the ability of supply chains to optimally balance cost, quality, service, resilience, and sustainability. The UK Government is actively working with business and international partners to protect company interests. Any company can make contact and try to expose their concerns. There is a need for regular updates on the outcomes of government consultations and business forums and for prompt awareness of the latest legal framework and regulations that have occurred.

IV. Conclusion

The conclusion summarizes the aim and objectives set and solved in the thesis. In the course of presenting this dissertation and in order to understand the impact of Brexit on supply chains, the theoretical essence of the concept of supply chains, supply chain management, supply chain disruption and supply chain recovery in the context of today's dynamic world are thoroughly examined. The author of the thesis also takes the liberty to provide her own broad definition of modern supply chains that reflects risks and uncertainty. To achieve the aims of the thesis, an in-depth analysis of Brexit scenarios and pre- and post-Brexit trade effects on UK supply chains has been conducted. A number of factors are examined which are identified in academic publications as having a major impact on supply chains in Great Britain when the country leaves the EU.

Based on the research carried out in this thesis, some observations can be drawn and *generalizations* made. Brexit has had a significant impact on supply chains in the UK since the referendum in 2016. With the announcement of the referendum result the British pound began to depreciate, which led to an increase in the cost of imported raw materials and components. As the UK's largest trading partner, the European Union plays a key role in supplying the UK economy, which has raised concerns about potential trade difficulties, reduced trade volumes, border delays due to customs checks, increased costs and a decline in manufacturing. Among the most affected industries are the pharmaceutical, food and automotive sectors, where JIT (Just-in-Time) supply chains, characterised by minimal inventories, are widely used. The UK has always been heavily dependent on workforce from the European Union causing skills shortages in key sectors such as healthcare, transport and agriculture. Anticipated challenges include increased administrative burdens, difficulties in finding new suppliers, inconsistencies in standards, loss of access to EU funding, customs checks and labour shortages. Impacts are also foreseen on investment, cybersecurity and sustainability. Given these factors, significant disruption to existing supply chains is expected, necessitating adaptation and strategic changes to minimise the negative impacts of the UK's exit from the European Union.

From 1 January 2021 the relationship between the UK and the EU is based on the Trade and Cooperation Agreement (TCA) with a new immigration system being introduced in parallel. Anticipated consequences are beginning to appear with negative impacts on domestic supply chains. Supply chain processes are disrupted and not executed on schedule due to delays at border crossings. The origin of goods has to be clarified, creating difficulties for suppliers and the need for new partners. The cost of production for companies in the UK increases. Small and medium-sized enterprises are particularly affected as they have fewer financial and human resources to adapt to the new conditions. The logistics sector is among the most affected with rising costs and additional administration creating significant challenges. One of the most serious problems is labour shortages. The lack of truck drivers is causing difficulties in the functioning of supply chains. In response to these challenges- the use of alternative routes and means of transport has begun, with a rise in the use of rail transport in Great Britain. Productivity in the country is falling between 2% and 5% due to all the negative factors (in comparison to a no-Brexit scenario) and the number of companies declaring bankruptcy is increasing significantly. End consumers are also feeling the effects of problems in supply chains through rising product prices and reduced range of products. Declining investment in the country is impacting the resilience of supply chains and there has been an increase in cyber threats related to their security.

The empirical research conducted in this thesis through Fuzzy AHP analysis provides a new perspective for reflection and an opportunity for deeper analysis on the effects of Brexit. The analysis is based on a survey filled in by supply chain professionals in Great Britain. This allows us to find out through a specific econometric toolkit which Brexit-related factors have had the most significant impact on supply chains in the country, but now according to the UK professionals. The results of the global weights analysis suggest that the most important factors are the new rules for seasonal workers, the visa points system, increased production costs and administrative bureaucracy The results of the Fuzzy AHP analysis resonate with the research in chapter two and the published statistics.

The dissertation also formulates recommendations that could help firms to cope with current challenges and create more flexible supply chains. For example, companies can increase the level of automation of key processes, which will contribute to the increase of flexibility of supply chains by reducing dependence on human resources. Possible is to look for alternatives to recruit staff

from outside the EU who meet the new visa requirements. The adequate solution to minimise the additional bureaucratic burden after Brexit is to outsource the administrative activities to third countries. The deployment of technologies such as blockchain to track documents and goods is also having a positive impact by helping to reduce tensions and risks in chains. Ensuring real-time tracking is key and this can be implemented through reports that are regularly updated through in-house data or through information from suppliers. Another recommendation relates to encouraging local production, as well as sourcing suppliers in geographical proximity to the company and supplier diversification. A good practice to improve the cybersecurity of supply chains is to regularly check the firm's own security systems, make insurance and regularly review the risks associated with suppliers and customers along the chain. Active dialogue is needed between supply chain partners in order to identify the most problematic factors and find ways in which government institutions can assist mitigating the negative consequences of the UK's exit from the European Union.

In conclusion, the thesis achieves its aims, purpose and proves the thesis that Brexit has had a significant impact on supply chains in Great Britain in terms of increased operational costs, labour shortages, extended delivery times and complicated administrative procedures. Validating the thesis through Fuzzy AHP analysis also highlights both the critical role that Brexit plays for the UK's trade relations with EU countries and the pressing need to regularly rethink the most impactful factors on supply chains in a crisis.

V. Scientific contributions

This dissertation is a timely and original piece of research in the area of the interrelationships between supply chains and the effects of Brexit.

This statement is supported by *the author's contributions* and more : *Theoretical and applied contributions*:

1. Based on a comprehensive and in-depth study of theoretical views on the nature and evolution of supply chains and their strategic management, the author's views are defined with a broader contemporary context. The interrelationship with the resilience of supply chains to negative events and the use of 'just-in-time' JIT chains and Lean Six Sigma methodology in the search for competitive advantage in supply chain management is outlined.
2. From a theoretical and applied perspective, the thesis explores the pre- and post-Brexit scenarios, the new immigration system and proves the effects on the supply chains due to the new UK-EU trade and cooperation agreement in terms of customs controls and tariffs; import dependence on raw materials in the consumer goods, pharmaceutical and automotive sectors; regulatory inconsistencies and potential divergence of standards; FDI and financial services and digital transformation, cyber security, data protection and environmental

Methodological and practical-applied contributions:

3. This thesis extends the scope of econometric methods used in the field of the relationship between supply chains and Brexit effects by using fuzzy AHP analysis to rank Brexit factors with an impact on UK supply chains.
4. As a result of the empirical research conducted, the thesis provides UK professionals with concrete suggestions for decision-making in a crisis, namely suggestions for addressing labour shortages as a consequence of the significant impact of the new seasonal worker rules and the new visa points system, and suggestions for cost optimisation and supply diversification as a consequence of the significant impact of increased production costs and administrative bureaucracy.

VI. List of publications on the topic of the dissertation:

1. Kaloyanova, G.*Disruptions in the Supply Chains - Factors, Effects and Risk Management.* [Electronic resource] Global and Regional Dimensions of International Economic Relations : Electronic Journal of SA "D. A. Tsenov" 2024, 1, 28-35, DOI 10.58861/tae.grdier.2024.03

2. Kaloyanova, G. *Supply Chain Disruptions in the United Kingdom Caused by Brexit*. Toward Green, Inclusive and Digital Growth: Management International Conference (MIC 2023), Koper: University of Primorska Press, 2023, 37-45, DOI 10.26493/978-961-293-306-7

3. Kaloyanova, G. *Impact of Brexit on the Supply Chains in the United Kingdom*. The Membership of Bulgaria in the European Union: Sixteen Years Later, October 2023, UNWE - Sofia: Vol. 2. Papers Presented in English Language, Sofia: Publishing Complex - UNWE, 2, 2024, 235-241

4. Kaloyanova, G. Effects of the End of Free Movement on the Supply Chains in the United Kingdom. Izvestia Journal of the Union of Scientists - Varna. Economic Sciences Series, Varna: Union of Scientists - Varna, 12, , 2, 234-240, ISSN(in press)1314-7390 , ISSN(online) 2603-4085, DOI 10.56065/IJUSV-ESS/2023.12.2.234

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