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SIMULATION-BASED SCENARIO PLANNING MODEL TO INVESTIGATE POST-BREXIT IMPLICATIONS ON THE IRISH BEEF EXPORT SECTOR: A CASE STUDY

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Introduction

Geopolitical disruption is considered a regular risk that hits supply chains and results in a long-lasting impact on a local, national, and global scale (Hendry et al., 2019a). They can limit access to personnel and interrupt transportation and distribution networks, as happened in the Hong Kong protest in 2019 that brought the whole country to a halt. Trade disputes result from such disruptions, cause a dramatic increase in raw materials prices, and influence firms' competitiveness in the home market (Roscoe et al., 2020). Brexit, for instance, creates disruptions to every aspect of supply chains. It affects trade volumes, supply chain assets, material and information flow, human resource availability, and access to suppliers. Besides, Brexit imposes barriers, red tapes, and controls for the trade between the UK and EU (including Ireland). These barriers are divided into tariff and non-tariff barriers. While tariff barriers introduce duties on the EU products sold on the UK market, non-tariff barriers challenge the freedom of movement for goods and services. They reintroduce customs and border controls on the borders entry points and sanitary and phytosanitary (SPS) checks on animal origin products. The EU applied full non-tariff barriers on the imported goods from the UK directly after the end of the transition period – January 2021. On the other hand, the UK decided to postpone implementing the non-tariff barriers at the ports linking with the EU until October 2021 and January 2022 due to Covid-19 disruption to businesses, Figure 1.

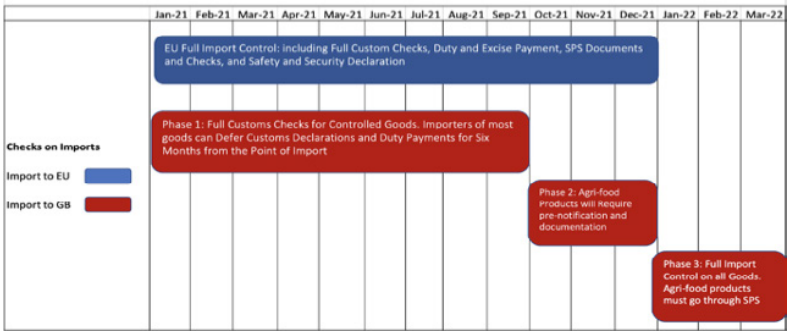

Figure 1 Phases of Non-Tariff barriers implementation at the GB and EU

The meat sector in Ireland is one of its most important indigenous industries as it generates total sales of around 4.5bn, with exports exceeding 4bn annually (Ibec, 2020). Irish beef exports to the UK are expected to severely disrupted post-Brexit if a trade agreement cannot be concluded. It will face high tariffs, additional administrative burdens, increased veterinary checks and sampling, and a rise in transport and shipping costs. As a result, a decline in Irish beef imported into the UK is expected, which would be highly challenging since Irish beef traders cannot replace the UK market. Predicting Brexit scenarios and assessing the implications on the Irish Beef trade is necessary for Beef exporters to prepare actions to mitigate risks and understand how businesses could be affected. Scenario planning is an effective tool to understand these risks since uncertainties are high, and decision-makers have little control over them (Peterson et al., 2003). Using simulation to plan and assess scenarios quantitatively is introduced in various application domains in the last decade (Alcamo, 2008; Pizzitutti et al., 2017). Simulating future scenarios models complex relationships and system dynamics. It allows verification of internal consistency and testing of policies, strategies, or particular actions (Symstad et al., 2017). Hence, this paper introduces a simulation-based scenario planning framework to support decision-makers in the Irish beef export sector. Post-Brexit scenarios may come into effect following the second and third phases of border checks, on October and January 2021, Figure 1. The research aims to provide the stakeholders in the Beef industry with a clearer vision on how the Beef supply chain in Ireland and the UK may be affected.

Literature Review

Global supply chains involve complex and dynamic interrelationships that expose buyers and suppliers to unique challenges and transportation risks (Alvarado-Vargas and Kelley, 2020; Lei et al., 2021). They are particularly affected by significant uncertainty arising from geopolitical disruptions (Niknejad and Petrovic, 2016; Roscoe et al., 2020). Geopolitical disruption is one of the most urgent global risks at present (Selmi et al., 2020). They are sometimes referred to as constitutional changes (Hendry et al., 2019b), regulatory disruptions (Phadnis and Joglekar, 2020), or political risks (Charpin et al., 2020). Such disruptions lead to structural shifts in demand and require firms to adapt their supply chains to new market conditions to remain competitive (Phadnis and Joglekar, 2020). Tariff and non-tariff barriers are significant risks of geopolitical disruptions that generate additional uncertainties and turmoil in the cross-border transportation flow of materials and goods (Alvarado-Vargas and Kelley, 2020).

Food supply chains (FSC) are complex networks of interdependent firms and actors involved in growing, processing, distributing, and trading food across the globe (Mena and Stevens, 2010). Also, FSCs take strict measures to maintain the integrity and minimise food scares through contamination or deliberate food crimes, adding to the complexity of food systems (Whitworth et al., 2017). The unique characteristics of FSC make it sensitive to natural and political disruptions that could cause costly product recalls, market withdrawal, and hunger for people in particular regions (Dani and Deep, 2010). A broad literature exists that highlights disruptions impact on food systems and supply chains (Hendry et al., 2019a). In the context of supply chain uncertainty, Van der Vorst et al. (1998) highlighted the importance of managing FSC uncertainty and presented improvement principles to boost the service level. The influence of unethical business practices such as (e.g., collusion) on FSC uncertainty has also been highlighted by Simangunsong et al. (2016).

Problem Context

The UK primarily imports high-priced cuts of Irish beef, with more chilled than frozen produce. Beef exports to the UK increased by 4% in 2018. In the European market in general, Irish beef exporters enjoy a similar trade position. The sector has seen growth in exports to the Netherlands and Italy, rising by 4% and 6%. Beef is unlike other products as its trade is not based on selling a carcass as a whole. Each carcass is divided into a range of cuts, which are then exported to various markets according to consumer demand. Each cut has a different value, so exporters must plan their supply chain to maximise revenue. In beef supply chains, retailers are the most powerful link. They provide competitive prices to consumers and thus exercise substantial power over the prices paid to processors and producers.

A limited shelf-life characterises the beef supply chain, so concerns have been raised regarding the potential challenges arising from Brexit. The shelf-life of chilled beef is dependent on the type of product. For example, specific beef cuts can have up to six weeks of shelf-life, while ready-meal products with beef ingredients may have only one week. Brexit brings various complications to the Irish Beef supply chain that will negatively impact its performance like;

- Veterinary health check and Custom controls: EU officials have applied SPS checks and other veterinary inspections on the meat imports to the EU27 from the UK in all EU ports on January 2021 – based on the EU official control legislation (Veterinary Check Directive 97/78/EC). Similar inspections are also expected to be applied by the UK on animal products entering their market from the EU27 on October 2021 and January 2022, Figure 1. The introduction of these inspections will inevitably cause an increase in transactional and transportation costs, border check fees, processing times at customs posts, and further administrative burdens on exporters and their agents.
- Accessibility to mainland Europe: The majority of Irish beef exporters using the UK as a landbridge to access mainland Europe since it is the fastest route and the most effective in terms of cost. Shipments that use direct route services, from Ireland to Cherbourg or Rotterdam, can take up to twice the transit time of those shipments that go through the UK landbridge and are subject to interruptions because of uncertain weather conditions. However, the UK landbridge's efficiency may diminish when the UK leaves the EU single market and customs union. Beef products will be subject to two transit checks at UK borders. To date, it is unclear what types of checks will take place on trucks transiting through the landbridge. Such uncertainty undermines the current control that operators have over their transportation times and costs, which subsequently disrupts the reliability of beef delivery and quality standards.

Research Methodology

The model focuses on the Ro/Ro (Roll-on/Roll-off) traffic between Ireland, the UK, and Continental Europe through two transportation routes, Figure 2:

- East/West maritime corridor: This combines several maritime routes which link the eastern Irish ports (i.e., Dublin and Rosslare) with UK ports through the Dublin-Heysham, Dublin-Liverpool, Dublin-Holyhead, Rosslare-Fishguard, and Rosslare-Pembroke maritime routes.
- Land-bridge route: This model shows the transportation links between Ireland and the EU26 through 1) the East/West maritime corridor, 2) transit routes to and from Holyhead, Liverpool, Heysham, Fishguard, and Pembroke ports, on the western side of the UK, and Dover Port on the south-eastern side, and 3) the maritime route, Dover-Calais, to the rest of mainland Europe.

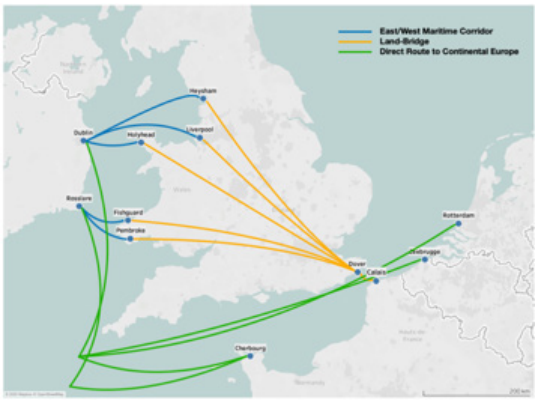

Figure 2: Transportation routes modelled in the simulation model

Before the simulation model, two conceptual models were developed to understand the processes of the transportation system between Ireland, the UK, and the EU. Mainly conceptual models include information related to the flow of inbound and outbound trucks, various check procedures (customs, SPS, and transit checks), and port operation systems. In the case of outbound flow (from Ireland to the UK or Continental Europe), the trucks started from an Irish-based supplier and moved toward the Irish ports. On arrival at Irish ports, the trucks roll on to the ferries, then based on ferries' frequencies and capacities, they sail to their destination ports. Upon arrival to their destined port, trucks roll off from the ferries and finish their journey either at a UK-based distributor or at an EU-based distribution, Figure 3.

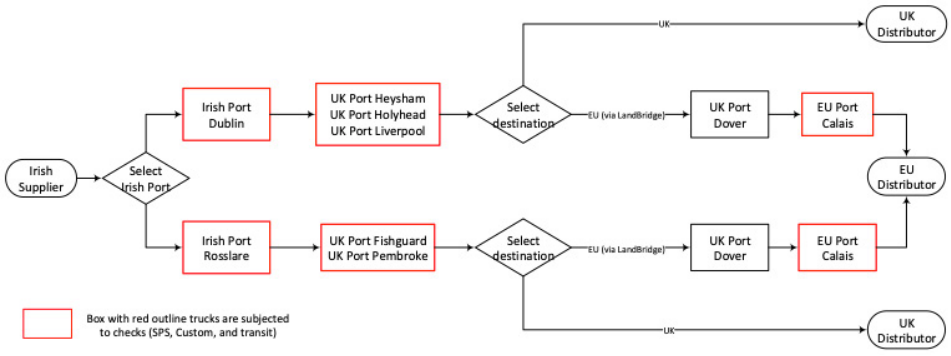

Figure 3 Outbound trucks flow from Ireland to UK or EU (via land bridge)

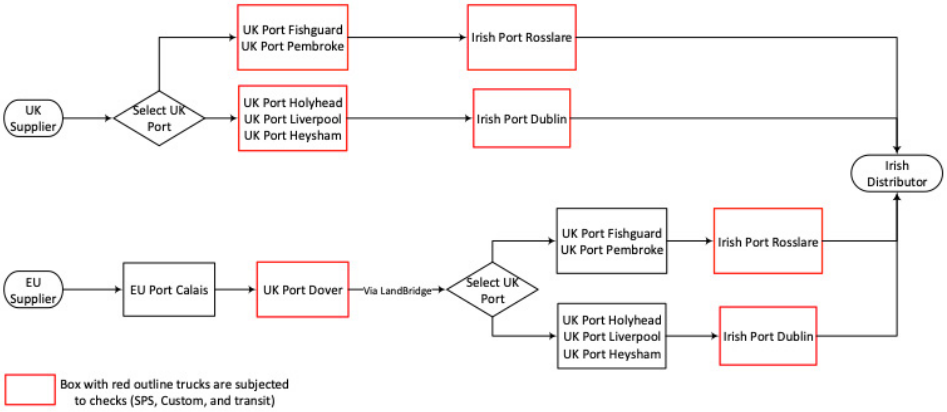

Figure 4 Inbound trucks flow from UK or EU (via land bridge) to Ireland

Similarly, in the inbound flow (from the EU or UK to Ireland), the trucks originating from either a UK-based or EU-based supplier. The trucks then pass through various ports depending on their routes and finish their journey at an Irish-based distributor, Figure 4.

Finally, a simulation-based scenario planning model developed using a hybrid approach (agent-based and discrete event simulation) based on a geographic information system (GIS) map in AnyLogic software. Specifically, agent-based modelling is used for interaction among 19 agents to mimic imports and exports between Ireland, the UK, and the EU. The agents include suppliers (the origin point generating the trucks), distributors (the destination point receiving the trucks), and port agents. Moreover, a leading agent was developed to manage the overall dynamics and interrelationships between the agents. On the other hand, discrete event modelling is applied for sequencing the processes inside the different agents. The simulation software can simulate road and maritime traffic routes and flexible enough to incorporate various trip times for other road and sea routes.

Scenario Analysis

The studied scenarios included introducing new border checks across the Irish Sea and applying transit checks on trucks using the landbridge. Three factors would influence the level of intervention and delay at UK ports: 1) the proportions of trucks selected for the border control checks; 2) the intensity and length of those checks, and 3) the accuracy of declarations and health documentation submitted. Two key performance indicators were used to quantify the impact of different interventions and delays:

- Transportation Time (total time taken by a truck from origin to destination)
- Remaining Shelf-life Time (i.e., transportation time subtract from total shelf-life)

Scenario 1- Level of border checks across the Irish Sea: This scenario applies non-tariff barriers to trade between Ireland, GB, and the EU, including documentary, identity, and physical checks. Three border checks scenarios at the UK ports were used: 1) Limited Check Delay, 2) Moderate Check Delay, and 3) High Check Delay. These three scenarios were tested and analysed with a baseline set as the pre-Brexit situation of trade named As-Is scenario (i.e., no border checks are applied). Table 1 shows the proportion of trucks checked, along with the check timing in each scenario.

The analysis shows how sensitive transportation times and the remaining shelf-life of products are to check delays at UK ports, Figure 5. A slight increase in truck transportation times is observed in the limited-check-delay and moderate-check-delay scenarios. However, the average truck transportation time increases by 234% in the high-check-delay scenario compared to the transportation time in the limited-check-delay scenario. The increase in transportation time disrupts the flow of beef exports for up to two days, which would have a devastating impact on Irish beef exports to the UK and affect the fresh beef supply chain in general. The average remaining beef shelf-life would be reduced by 9% in the high-check-delay scenario. The reduction in shelf-life would significantly lose the value of products, quality standards, and competitiveness (e.g., mince beef and fresh ready-meals).

Table 1: Levels of Borders Checks

Scenarios	Description
As-Is	• No trucks are directed to any checks at the UK ports
Limited Check Delay	• 100% of consignments going for documentary and sealed identity checks (check timing is 20min/truck). • 10% of the trucks carrying beef are directed to physical checks (check timing is 60min/truck).
Moderate Check Delay	• 100% of consignments going for checks, and check timing is 30min/truck. • 20% of the trucks carrying beef are directed to physical checks (check timing is 90min/truck).
High Check Delay	• 100% of consignments going for checks, and check timing is 45min/truck. • 30% of the trucks carrying beef are directed to physical checks (check timing is 135min/truck).

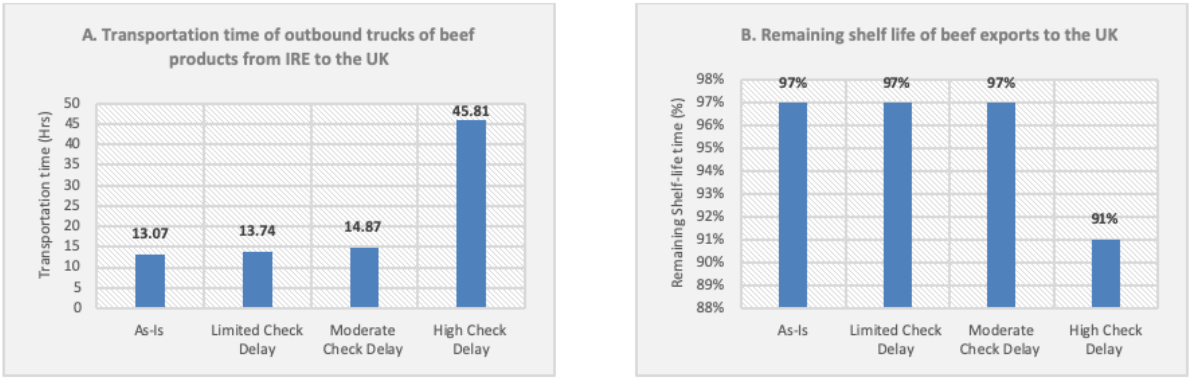

Figure 5 Level of Borders Checks Implications on the Transportation Flow

Scenario 2-Level of transit checks: The analysis in this section aimed to investigate various levels of transit checks and quantify their impact on fresh beef exports to Continental Europe, Table 2. Exports from Ireland to mainland Europe will be subject to transit checks at western UK ports. It is assumed that the number of offices of transit in each port will be two, and all will have paper-based transit procedures (i.e., all trucks must present their transit accompanied documents (TADs) and goods upon arrival at the ports). The model showed a slight interruption to Irish beef exports to mainland Europe via the UK landbridge in three transit check scenarios. The transportation time increased by around 1.5 hours and 5 hours in the moderate-transit-check-delay and high-transit-check-delay scenarios, respectively, Figure 6. The remaining shelf-life for beef was reduced by just 1% under the more extended transit check scenario.

Scenarios	Check timing (in min)	Description
As-Is	0	• No transit checks.
Limited Transit Check Delay	5	• Regular checks on transit accompanying documents.
Moderate Transit Check Delay	15	• More checks are required on the permissions for the operator to transit via UK territory.
High Transit Check Delay	25	• Further increase in transit checks timings

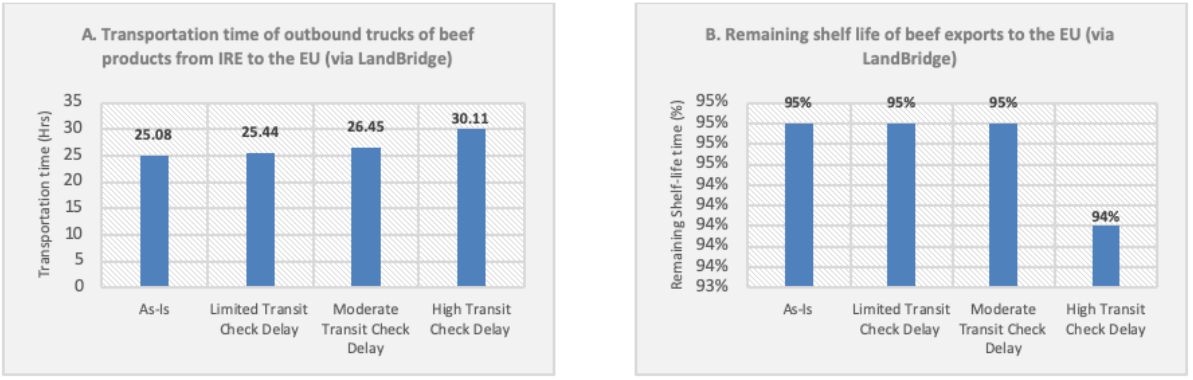

Figure 6 Levels of Transit Checks Implications

Discussion and Conclusion

Trade barriers, including tariff and non-tariff barriers, are expected to damage the beef trade partnership between Ireland and the UK. Beef exporters cannot see any opportunity to replace the UK market with other markets in Europe or beyond, considering that the beef supply chain with the UK is well established and has worked efficiently for many years. The strong ties between the two countries and the level of beef trade with the UK – 50% of Irish beef exports – mean that the UK cannot be replaced with any other countries or trade regions. The procedures of customs, veterinary, and immigration checks at UK ports post-Brexit, and the intensity of these checks (i.e., level of check intervention and check delay), is still unclear. The UK authorities have provided limited formal information. Companies anticipate longer waiting times for their freight at the UK's customs and veterinary checkpoints and transit offices. According to research estimations, truck delays could increase to two days if high check interventions with longer check delays are imposed. This delay could disrupt the whole supply-chain operation, particularly for limited shelf-life products. Changes in demand volumes and inventory strategies are foreseen to create a buffer against delays in product delivery. Retailers will plan their demand further to hold more stock and review the effectiveness of the just-in-time delivery strategy under the new border regimes. Demand for refrigerated trucks and containers will also grow since beef exporters will seek to maintain product freshness and avoid product spoilage.

Further, more than 90% of Irish meat exports to mainland Europe flow via the UK landbridge. It provides hauliers with more control over transit time and speed delivery to EU26 markets. Introducing new transit checks for trucks entering the UK will complicate freight transit via the UK landbridge and increase transit costs. Compared to the As-Is situation, transit checks could add to the freight transportation time based on check types and the intensity of checks. Recently, Covid-19 related procedures at European ports showed an example of what would happen at borders if more forms and checks are required. Filling in a simple form manually before crossing to Dover led to miles and miles of trucks queuing at Calais and considerable disruption to the supply chain. The level of uncertainty inherently associated with Brexit may arise unforeseen effects beyond the considered variables in the study. Beef exporters may respond to this uncertainty by reviewing their supply chain designs, opting for direct service to the continent, or shifting the trade to other markets. Further research is recommended to assess these potential scenarios and apply the utilised research methodology to support other economic sectors against Brexit risk.

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