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Lucile Henry

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THESE DE DOCTORAT DE

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Par
Lucile HENRY

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"In the long run we are all dead. Economists set themselves too easy, too useless a task if, in tempestuous seasons, they can only tell us that when the storm is long past the ocean is flat again."

John M. Keynes – *"A Tract on Monetary Reform"*, Ch. 3, p. 80, 1923

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List of Abbreviations

English abbreviations

APEC: Asia-Pacific Economic Cooperation.
AVE: Ad-Valorem Equivalent.
AVTC: Ad-Valorem Trade Cost.
CAP: Common Agricultural Policy.
CES: Constant Elasticity of Substitution.
CET: Common External Tariff.
CETA: Comprehensive Economic and Trade Agreement.
CGEM: Computable General Equilibrium Model.
CIF: Cost, Insurance, and Freight.
COVID: Corona Virus Disease.
CSO: Central Statistics Office.
CU: Customs Union.
EC: European Commission.
ECSC: European Coal and Steel Community.
ECU: European Currency Unit.
EEC: European Economic Community.
EFTA: European Free Trade Association.
EIA: Economic Integration Agreement.
EMU: Economic and Monetary Union.
ERM: Exchange Rate Mechanism.
EU: European Union.
FDI: Foreign Direct Investment.
FE: Fixed Effect.
FOB: Free On Board.
FR: Freight Rate.
FTA: Free Trade Agreement.
FTAA: Free Trade Area of the Americas.
GATT: General Agreement of Tariffs and Trade.
GB: Great Britain.
GDP: Gross Domestic Product.
GSP: Generalized System of Preferences.

HOS: Heckscher-Ohlin-Samuelson.
HS: Harmonized System.
IMF: International Monetary Fund.
IMR: Inward Multilateral Resistance.
ITGS: International Trade in Goods Statistics.
ITIC: International Transport and Insurance Costs.
LDC: Least Developed Countries.
LoLo: Lift on/Lift off.
MFL: Multinomial Fractional Logit.
MFN: Most Favored Nation.
MR: Multilateral Resistance.
MTA: Multilateral Trade Agreements.
NI: Northern Ireland.
NTM: Non-Tariff Measure.
OECD: Organisation for Economic Cooperation and Development.
OMR: Outward Multilateral Resistance.
PPML: Pseudo-Poisson Maximum Likelihood.
PTA: Preferential Trade Agreement.
RoRo: Roll on/Roll off.
RTA: Regional Trade Agreement.
SITC: Standard International Trade Classification.
SPS: Sanitary and Phytosanitary.
TBT: Technical Barrier to Trade.
TPP: Trans-Pacific Partnership.
TRAINS: Trade Analysis Information System.
TRQ: Tariff-Rate Quota.
TTIP: Transatlantic Trade and Investment Partnership.
UK: United Kingdom.
UKGT: United Kingdom Global Tariff.
UKIP: United Kingdom Independence Party.
UN: United Nations.
UNCTAD: United Nations Conference on Trade and Development.
US: United States.
USA: United States of America.
USSR: Union of Soviet Socialist Republics.
UV: Unit Value.
WTO: World Trade Organization.
WWI: World War I.
WWII: World War II.

Abréviations françaises

ANIA: Association Nationale des Industries Alimentaires.
BACI: Base pour l'Analyse du Commerce International.
CA: Chiffre d'Affaires.
CEPII: Centre d'Études Prospectives et d'Informations Internationales.
CERDI: Centre d'Études et de Recherches sur le Développement International.
CESER: Conseil Économique, Social et Environnemental Régional.
CPF: Classification de Produit Française.
DRAAF: Direction Régionale de l'Alimentation, de l'Agriculture et de la Forêt.
FMI: Fond Monétaire International.
IAA: Industrie Agro-Alimentaire.
INSEE: Institut National de la Statistique et des Études Économiques.
MCO: Moindres Carrés Ordinaires.
MNT: Mesure Non Tarifaire.
MS: Member State.
OMC: Organisation Mondiale du Commerce.
OTC: Obstacle Technique au Commerce.
PAC: Politique Agricole Commune.
PIB: Produit Intérieur Brut.
RU: Royaume-Uni.
RML: Résistance Multilatérale.
UE: Union Européenne.
SH: Système Harmonisé.
SPS: Sanitaire et Phyto-Sanitaire.
TDC: Tarif Douanier Commun.

General Introduction

1 International trade and economic integration in theory and practice

1.1 History of economic thought and trade theory: why do we trade?

The barter of goods or services among different people is an age-old practice. International trade, however, refers specifically to an exchange between members of different nations, and the use of money. Attempts to explain international trade began with the rise of the modern nation-state during Middle Ages. A first interpretation is offered by the mercantilism, with a peak of influence in the XVIth and XVIIth centuries, followed by a shift towards liberalism, from the middle of the XVIIIth century, with the physiocrats and the classics. Mercantilism was based on the conviction that national interests are inevitably in conflict, that one nation can increase its trade only at the expense of other nations. A strong reaction against mercantilist attitudes began to take shape towards the middle of the XVIIIth century. Among the liberalists, the classics mark the advent of the modern economy. Adam Smith, a XVIIIth century Scottish economist, philosopher, and author, is considered the father of modern economics. He is mainly known for his ideal of an invisible hand, advocated in his first book, *"The Theory of Moral Sentiments"* (1759), and consisting in the tendency of free market to regulate itself by means of competition, supply and demand, and self-interest. But he also contributed a lot to the field of international trade, especially in his masterpiece *"The Wealth of Nations"* (1776), where he demonstrated the advantages of removing trade restrictions. He also illustrated the importance of specialization in production with the absolute advantage theory. He is one of the first thinkers to advocate free trade. Here is a short extract of Adam Smith founding book *"The Wealth of Nations"* illustrating and discussing the absolute advantage theory: *"By means of glasses, hotbeds, and hotwalls, very good grapes can be raised in Scotland, and very good wine too can be made of them at about thirty times the expense for which at least equally good can be brought from foreign countries. Would it be a reasonable law to prohibit the importation of all foreign wines, merely to encourage the making of claret and burgundy in Scotland?"* Smith, 1776, The Wealth of Nations, Book IV, Chapter II, p. 458, para. 15.

Just few years after Adam Smith's absolute advantage theory, David Ricardo improved the terms-of-trade concept by taking cross-country technology differences as the basis of trade. He introduced the principle of comparative advantage: comparative advantage exists when a country produces a good or service for a lower opportunity cost than other countries, opportunity cost measuring a trade-off. A nation with a comparative advantage makes the trade-off worth it, *i.e.* the benefits of buying its goods or services outweigh the disadvantage. The country may not be the best at producing something, but the goods or services have a low opportunity cost for other countries to import. Comparative advantage refers then to a country's ability to produce goods and services at a lower opportunity cost than that of

trade partners. It is determined by relative endowments of the factors of production, such as land, labor, and capital.

The new inequality between relative factor endowments inspired the Heckscher–Ohlin–Samuelson (HOS) trade theory. The latter builds on David Ricardo's theory of comparative advantage by predicting patterns of trade and production based on the factor endowments of a trading region (Feenstra, 2004). The model essentially says that countries export products that use their abundant and cheap factors of production, and import products that use the countries' scarce factors.

Traditional models of trade, such as those based on Ricardo and HOS theory, explain trade entirely by differences among countries, especially differences in their relative endowments of factors of production, and are focused on gains from specialization by comparative advantage and assume perfect competition. Later, according to Helpman and Krugman (1985), this traditional approach was criticised for its ineffectiveness in explaining the trade flow between industrialised countries and the exchange in differentiated products. The inability of old trade theories to explain trade between similar countries prompted the developing of an alternative approach called the new trade theory.

In a world where increasing returns are present, comparative advantage resulting from differences between countries is not the only reason for trade. While increasing returns are inconsistent with perfect competition, an imperfect competition framework was needed (Helpman and Krugman, 1985). In particular, Dixit and Stiglitz (1977) introduced the consumer preferences as a constant elasticity of substitution (CES) utility function between all varieties available to consumers, in a monopolistic competition model, where firms face increasing returns to scale due to a fixed cost of production, instead of differences in factor endowments or technology. In this approach, trade and gains from trade can occur even between countries with identical tastes, technologies and factor endowments. In this new theory, all firms are identical, and the number of representative firms is linked to the economic mass of the considered country. But with the increasing trade liberalisation, it appeared that some firms are not able to cope with international competition while others thrive. The resulting intra-industry reallocations of market shares and productive resources are much more pronounced than inter-industry reallocations driven by comparative advantage. In this context, the growing need to emphasize firm level differences in the same industry of the same country will give birth to an other trade theory.

The *"new new"* trade theory was born. The emergence of this theory was also favored by the increasing availability of micro data since the end of the 1990's, revealing the high heterogeneity among firms, and the importance of firm characteristics and individuality. The representative firm assumption was no longer relevant, and the firm heterogeneity

is introduced in a monopolistic competition model. In a seminal paper, Melitz (2003) considers that firms are heterogeneous in terms of productivity and face fixed costs to enter production and to export. Other criteria can be considered, but productivity, together with the fixed costs, is a key characteristic, especially to determine whether a firm belongs or not to the selective club of exporting firms (Marcias, 2015). Fixed costs prevent many firms from exporting, and only the more productive firms can recover the fixed costs. In addition, one of the crucial advantages of the Melitz (2003) model is its tractability, which makes it possible to bring together microfacts and macro analysis (Hornok and Koren, 2017).

The above international trade theories are simply different theories to explain international trade. More precisely, two main questions have been and are still addressed in the international trade literature: (i) why do we trade, *i.e.* what are the determinants? (ii) what or how much do we gain from trade? which is, according to Arkolakis et al. (2012), the old and central question in international trade. Along these theoretical developments, there is also a huge literature concerning empirical studies. Among them, introduced by Tinbergen (1962), the gravity model is the workhorse empirical model for analyzing the determinants of the bilateral trade, but also for quantifying the impacts of trade policies on trade. [1]

1.2 Gravity, a workhorse for analyzing bilateral trade flows

Standard gravity

The favorite empirical tool to analyse the determinants and measure the welfare gains in the international trade literature is the empirical gravity model of trade. The name is derived by association with Newton's law of universal gravitation. It says that the gravitational force F_{ij} acting between two objects i and j is proportional with the masses of the objects, M_i^α and M_j^β, and inversely proportional to the distance between the centers of their masses D_{ij}^θ , with $\alpha = \beta = 1$ and $\theta = -2$. Economists have observed that, similarly to the universal law of gravity in physics, large and closely situated countries trade considerably more with each other than the rest. Applied to international trade, the simplest version of gravity is based on the same but revisited equation: the amount of trade X_{ij} between countries i and j is proportional to the economic sizes of the countries, usually measured by their gross domestic product (GDP) Y_i^α and Y_j^β, and inversely proportional to the distance between the two economies, d_{ij}^θ. In the literature, estimated values of α and β are closed to 1 and $\theta = -1$. [2]

Gravity equations are a model of bilateral interactions in which size and distance effects enter multiplicatively. In the simplest form of the trade version, bilateral trade between two

1. And the impacts on welfare but this aspect is out of our scope.
2. Concerning the distance effect θ, Disdier and Head (2008) examine 1 467 distance effects estimated in 103 papers. There is some amount of dispersion in the estimated distance coefficient, with a weighted mean effect of -1.07 (the unweighted mean is -0.9), and 90% of the estimates lying between -0.28 and -1.55. Despite this dispersion, the distance coefficient has been remarkably stable, hovering around -1 over more than a century of data. The mean value of θ being -0.9, it indicates that on average bilateral trade is nearly inversely proportionate do distance.

countries is directly proportional to the product of the countries' GDP and inversely proportional to the distance (Head and Mayer, 2014). In the most basic gravity model, distance is used as a proxy for transport costs, and more generally for all trade costs. But in order to account for as many factors as possible, it is common to augment the traditional gravity model with additional variables reflecting other trade costs, not necessarily proportional to distance, *e.g.* import tariffs or dummies for regional trade agreements (RTAs) or preferential trade agreements (PTAs), common language, contiguity, or colonial history.

Structural gravity and multilateral resistances

Different specifications of the gravity model have been used for the analysis of the bilateral trade flows. At the beginning, even if it was one of the most empirically successful in economics, the gravity model had no theoretical foundations. In addition, it was not compatible with old trade theories. While only bilateral trade costs were taken into account, the need to satisfy equilibrium constraints, at country level but also at the global level, shows that indirect multilateral effects do exist too, and have to be taken into account.

Anderson (1979) was the first to offer a theoretical economic foundation for the gravity equation under the assumptions of product differentiation by place of origin. He showed that the gravity equation can be derived from the properties of demand systems. The constraints imposed in the structural gravity framework are equivalent to adding-up constraints of balanced trade. This new structural definition of gravity was then developed by moving away from the intuitive traditional definition and by explaining trade as a part in the total expenditures of an economy. It was followed by Bergstrand (1985, 1989) and Helpman (1987).

Despite these theoretical developments and its solid empirical performance, the gravity model of trade struggled to make much impact in the profession until the late 1990's and early 2000's. Arguably, the most influential structural gravity theories in economics are those of Eaton and Kortum (2002) and Anderson and Van Wincoop (2003). Eaton and Kortum (2002) derived a gravity equation in a modern version of trade driven by Ricardian comparative advantages, with intermediate goods and a technological heterogeneity accross countries separated by geographic barriers. This formulation leads to a tractable and flexible framework for incorporating geographical features into general equilibrium analysis. Anderson and Van Wincoop (2003) first popularized the Armington-CES model of Anderson (1979) and emphasized the importance of the general equilibrium effects of trade costs. They introduced the multilateral resistance (MR) terms in the model, in order to capture the average trade barriers that both regions face with all their trading partners. They were followed by Bernard et al. (2003); Chaney (2008); Eaton et al. (2011) and Anderson et al. (2018). According to Fally (2015), the constraints imposed on MR indexes constitute the key difference between the structural gravity model and the standard

or even reduced-form gravity, with simple fixed effects by exporter and importer.

Since the structural version of the gravity ermerged, the combination of being consistent with theory and quite easy to implement leads to a rapid adoption in empirical work. The structural gravity framework is particularly appropriate to address the two questions raised before: (i) analyse the determinants of bilateral trade, *e.g. ex-ante* estimation of the potential impacts of a future deeper or shallower liberalization, and (ii) quantify the impacts of trade policies on trade and welfare, *e.g. ex-post* assessment of the impact of liberalization on trade flows between partners or on welfare. In addition, structural gravity models are applicable to different types of analysis, depending on data availability, from micro to macro level.

Trade frictions

International trade frictions, or trade barriers, are of vital importance because they determine trade patterns and therefore economic performance. A standard way of modelling trade costs is by assuming that a fraction of the goods shipped *"melts in transit"*. This is the so-called iceberg trade costs hypothesis, introduced by Samuelson (1954) and first included in a monopolistic competition model by Krugman (1980). Iceberg trade costs mean that for each good that is exported a certain fraction melts away during the trading process as if an iceberg were shipped across the ocean. Total trade costs equal the cost of producing these *"melted goods"*. Iceberg costs can be interpreted as an ad-valorem tariff equivalent for trade costs.

This hypothesis has the advantage to express trade costs as a destination-specific percentage of the good's producer price in i, with a multiplicative structure. This multiplicative structure allows to separate transportation costs effects from other factors. In practice however, the iceberg assumption has some limitation, *e.g.* in addition to ad-valorem (iceberg) multiplicative trade costs (such as insurance, ad-valorem tariffs) we also observe some additive cost components (such as shipping costs, specific tariffs), depending on the total volume (Hummels, 2007; Hummels and Skiba, 2004; Irarrazabal et al., 2015).

Focus on transport costs and gravity

The structural gravity model allows inference about unobservable trade costs by linking trade costs to observable cost proxies. Traditionally, and following the iceberg assumption, distance is used in the gravity model as a proxy for transport costs. But this approximation has some limitations. First, empirical evidence suggests that the distance variable in gravity estimations actually accounts for much more than just transportation costs (Head and Mayer, 2013). Second, transport costs can differ greatly across the different transport modes and products considered. For instance, road transport costs are usually higher than the maritime ones. Third, the time cost is usually put aside or considered as included in the distance variable. This approximation can lead to underestimate the transport costs impacts, which nevertheless have a major role in trade enhancement or weakening. According

to Hornok and Koren (2017), firms are willing to pay significantly above the interest cost to get faster deliveries. Hummels and Schaur (2013) estimate that USA importers pay 0.6–2.3% of the traded value to reduce trading time by one day. Other empirical studies that use different data and methodologies also confirm the importance of time costs in trade (Djankov et al., 2010).

Historically, the technological revolution in the transport sector has led to an important fall in transport prices, explaining, in part, the impressive trade growth over the last decades. Since 1950, goods have been transported faster, further and at a lower cost. [3] This transport revolution was combined with an increase in the level of trade liberalization (Marcias, 2015).

2 Brexit, a globalization halt?

2.1 Free trade and trade integration evolution

Since Adam Smith, international trade theory evolved, but still highlights the gains for countries to adopt free trade. The desire of showing the positive impact of free trade on a society's welfare has been one of the key elements that have motivated the birth of international economics. In addition to free trade promotion, the development of efficient tools allowing to assess trade policies have definitely influenced the policies adopted by each country, most oftenly towards more free trade, with some notable exceptions.

In the last few centuries, particularly the XXth and XXIst, countries have entered into several pacts to move towards free trade with periods of return to protectionism. For example, there was dramatic disintegration during World War I (WWI), gradual reintegration during the 1920's, and a substantial disintegration after 1929. The post-1929 period saw the unravelling of many of the integration gains over the 1870–1913 period (Hynes et al., 2012; Milanovic, 2002). But in the same time, after the WWI, the need to reduce the pressures of economic conditions and ease international trade between countries gave rise to the World Economic Conference in May 1927 organized by the League of Nations. The largest industrial countries participated and projected the idea of multilateral trade agreements. This was materialized with General Agreement of Tariffs and Trade (GATT) after the World War II (WWII), in 1947, signed by 23 countries. The number of signing countries increased significantly after 1947. In 1995, the GATT became the World Trade Organization (WTO). After the interwar disintegration episode, a vast movement of deep integration emerged. The post war integration, from 1945, has been particularly fast.

3. The always wider use of containerized shipping facilitated and secured long distance hauls. The containerization allowed easier transshipment between various transport modes without needing to be unpacked or stored and hence this resulted in faster and cheaper transport. The adoption of jet engines in the air transport lead to a substancial drop in the aviation costs (Marcias, 2015).

Since 1945, the GATT, then the WTO, have been promoting free trade and a greater liberalization. Non-discrimination among trading partners is one of the founding principles of the GATT (WTO). [4] It promotes an equal trade openness to all countries, expressed in the most favored nation (MFN) treatment. [5] MFN means that a country cannot offer better trading terms to one country and not to WTO members. Reciprocal preferential trade agreements between two or more partners (RTAs or PTAs) constitute one of the exemptions and are authorized, subject to a set of rules. They also aim at trade liberalization, and are restricted to a small number of countries. After the WWII, to achieve greater trade liberalization, trade costs such as tariffs have been lowered significantly, and RTAs and PTAs have risen in number and reach over the years.

Beyond pure trade agreements, economic integration has also increased significantly since the end of the WWII. Economic integration involves cooperation in other sectors (*e.g.* services, investments, intellectual property rights), as well as mutual recognition of standards or regulations, *etc*, going up to the harmonization of countries' policies in different economic areas, such as social. Some negotiations were conducted between trading blocs, whose outcome was still promising in the 1990's and 2000's, but have been abandoned after a change in USA's policy, [6] or have remained at the level of discussion forum. [7] As a result, countries have intensified negotiations within trade blocs.

Currently, most of the countries are WTO members. In addition, most of them have signed trade agreements with other countries. Some countries are involved in several RTAs at the same time. Combined with the reduction of trade costs (not only transport costs, but also and mostly information and communication costs), these policies have led to an unprecedented intensification of trade flows, fragmentation and interconnection of production processes, called globalization. This globalization, reinforced by the activity of multinational firms and the progress of information and communication technologies, also impacts other areas, *e.g.* standardization of consumption habits, tastes, cultural trends, *etc*. More broadly, globalization refers to the increasing global relationships among countries in different areas, such as culture or economic activity.

Quantitative and detailed trade policy information and analyses are more necessary nowadays than they have ever been. In recent years, trade liberalization and globalization have become increasingly contested. It is, therefore, important for policy-makers and other trade policy stake-holders to have access to detailed, reliable information and analyses of the effects of trade policies, as theye are cornerstone elements for designing the optimal policies.

4. https://www.wto.org/english/tratop_e/region_e/region_e.htm
5. https://www.gov.uk/guidance
6. For instance: Transatlantic Trade and Investment Partnership (TTIP), Trans-Pacific Partnership (TPP), Free Trade Area of the Americas (FTAA)
7. For instance: Asia-Pacific Economic Cooperation (APEC)

To sum up, global trade and economic integration have continuously grown since the end of the WWII, with some sporadic exceptions. In this context, Brexit is an unprecedented episode of "*disintegration*" in the modern history.

2.2 A disintegration episode called Brexit

By all the odds, June 23, 2016 will remain engraved in the memory of many people. It was the date of the United Kingdom (UK) referendum to stay or leave the European Union (EU). The outcome of the vote has been a big surprise for many people. 17.4 million British voted to leave the EU and only 16.1 million to remain. David Cameron resigned as Prime Minister, and the long and challenging way towards Britain's exit from the EU, namely Brexit, started. Since then, Brexit has been and is still a quite hot topic, unleashing passions and giving rise to heated debates, threats of disaster scenarios, *etc*.

After several surprises and reversals during negotiations, Brexit day actually happened on January 31, 2020 but nothing concretely changed, as the withdrawal agreement stipulated a transition period lasting until December 31, 2020. During this period, the UK must comply with the EU rules and laws. The transition period was introduced in order to give more time to businesses in the UK and the EU to prepare for the new agreements or the absence of an agreement between the EU and the UK. If no additional delay is jointly decided, from January 1, 2021, the UK will no longer benefit from its trade agreements, whether or not an agreement is reached on the new relationship between the UK and the EU.

Here we are witnessing one of the rare declines in the level of integration since the WWII, with the re-establishment of trade costs between countries. The EU is currently ruled by a deep integration, *i.e.* low trade costs between members but also harmonized economic policies. We can assert that post-Brexit trade costs between the UK and the EU will raise; we just don't know the magnitude and their exact nature. We focus on trade but consequences could be huge in other fields, such as people migration, tourism, research and teaching collaborations, *etc*. All sectors of the economy will be affected.

3 Importance and vulnerability of agri-food production and trade in the European Union

3.1 Agricultural and food sectors in the EU member states

For the EU, the agricultural and food sectors are highly strategic. Historically, support to the agricultural sector was one of the bases of the creation of the European Economic Community (EEC), ancestor of the EU, in 1957. A system of agricultural subsidies was implemented, led by the Common Agricultural Policy (CAP), created in 1962, and representing a large share of the EEC (and later EU) budget.

More generally, after the WWII, trade has been liberalized, in order to enhance European and world trade, and increase welfare. As the EU is very protective concerning its agricultural and food sectors, and promotes food self-sufficiency, these sectors have been only partially and belatedly liberalized for third countries. Within the EU, the gradual removal of intra-EU tariffs and the important subsidies did allow to lower food prices and achieve these goals, *i.e.* reach food self-sufficiency and boost trade between members, and also led to a rapid modernization of European agriculture, and a successful economic integration in Europe.

Today, the European agri-food sector still relies on substancial CAP support, but following the achievement of CAP's initial objectives, its goals have evolved. For example, the objectives of sustainability and territorial cohesion were put forward with the consolidation of rural development measures. More precisely, in 1999 it has been decided to complete the dimension of the CAP relative to the support of agricultural markets and prices, which is the *"first pillar"* of the CAP, with a *"second pillar"* devoted to rural development, aiming to support actions relative to climate change, agri-environment, or organic farming.

More recently, Brexit is raising additional and novel questions, as the UK, one of the main contributors, will no longer participate to the CAP budget. Not only will the UK farmers lose a large amount of CAP subsidies, [8] but it also could give rise to changes or reorganizations in the CAP system and then in the future agricultural and food sector policy. We do not know the future magnitude of these changes and their consequences. Even if this aspect is out of the scope of the present thesis, the CAP history allows to understand why the EU agricultural and food sectors have been and still are significant and strategic for the member states.

We take two figures as illustration. In 2015, the EU28 agri-food industry value-added represented 13.2% of the manufacturing industry value-added. [9] The EU27 (*i.e.* excluding

8. After Brexit, the UK will continue for several years (until 2022) the payment of subsidies to farmers hitherto paid by the EU until a new agricultural policy is established.
9. https://www.insee.fr

the UK) agricultural exports to third countries represented in 2019 181.8 billion euros, and 8.5% of EU27 total trade with extra third partners, with the surplus of the agri-food trade balance increasing over the last decades. [10]

The UK is an important EU27 trade partner. It is a net importer of agri-food products and an important destination market for EU27 agri-food exports. As a result, a change in trade policy (post-Brexit, depending on the outcomes of the EU-UK trade negotiations) is likely to have important repercussions on this sector, at both the UK and European levels, especially for the UK main partners. We focus on two of them: France, with a special emphasis on one of its main agricultual and agri-food region, namely Brittany, and Ireland.

3.2 Agricultural and food sectors in France and Brittany

France

The agricultural sector now occupies only a marginal place in the French economy in terms of GDP (less than 2% of the French GDP) and employment, like most developed countries in the world. However, as already discussed, this observation must be qualified by emphasizing the decisive role of the French agricultural sector in maintaining food self-sufficiency and in its contribution to the country's trade balance, as well as in terms of territorial dynamism [11] for attracting tourists and for promoting the image of France on the global arena. [12]

France is a major exporter of agricultural and food products (26% average export rate, measured by the percentage of sales made abroad, for a firm or sector), and the agri-food sector is one of the major industrial sectors in the French economy. First employer in the manufacturing industry, with more than 18 000 companies and 380 000 employees, first industry in terms of turnover, the agri-food industry is a major player in the French economy and a vector of competitiveness and attractiveness at the national, European and global levels. [13] Figure 1 gives the France's ranking (compared to other EU countries) for agricultural and food production, and some export statistics for the flagship products, namely, among others, beef, poultry, cheese, wine, and cereals. For instance, France is the first European producer of beef, surimi, beet sugar and cereals, and the first European exporter of potatoes.

Brittany, a leading French region in food production, industry and trade

Brittany is a leading French, but also European region in terms of agricultural production, turnover of agri-food industries and food trade. This region is composed of four departments: Côtes-d'Armor, Finistère, Ille-et-Vilaine and Morbihan (see Figure 2). In addition to

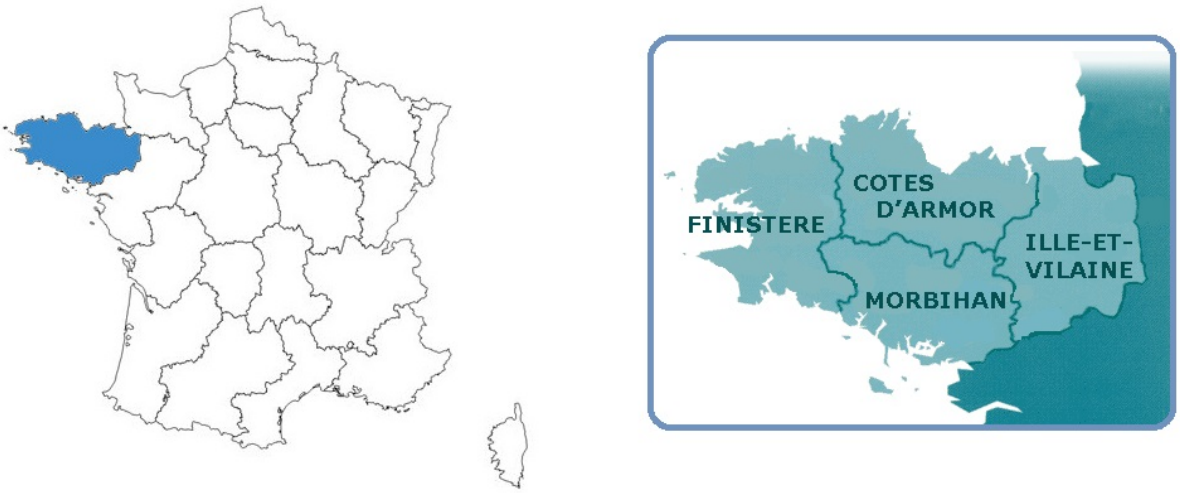
10. https://ec.europa.eu/eurostat
11. https://chambres-agriculture.fr
12. Promotion of the French "*terroir*" and gastronomy, and the idea that French food is good and sophisticated.
13. https://agriculture.gouv.fr

Figure 1: France's rankings for agricultural and agri-food production in the EU

Source: https://agriculture.gouv.fr

being France's chief farming region, Brittany is also the country's most important region for agri-food employment. With more than 58 000 employees, the agri-food industry employs one third of the working population in Brittany. It also accounts for 15% of French agri-food employees. The agri-food industry of Brittany has a turnover of more than 15 billion euros in its four main sectors of excellence: meat, animal feed, fruit and vegetables, and dairy products. Brittany holds a prime position in these sectors on both the national and international markets. For instance, Brittany produces 48% of France's pork, poultry and beef. On the international stage, Brittany accounts for more than half of French meat exports. [14]

Figure 2: Brittany region and its four departments



Source: https://fravatoutca.wordpress.com

Brittany and more generally France are areas whose economy is largely based on agri-food production and trade. The UK is a privileged trade partner for both of them. The British market is the third destination of French agri-food exports, after Germany and Belgium, absorbing 9.4% of French worldwide exports in this sector. [15] But the UK is also the fifth destination of Brittany's agri-food exports (326 millions euros in 2015), behind Italy, Spain, Belgium-Luxembourg and Germany. [16]

3.3 Agricultural and food sectors in Ireland

The agri-food sector is one of Ireland's most important manufacturing sectors. According to Teagasc, [17] in 2016 the Irish agri-food sector (including agriculture, food, drinks and tobacco as well as wood processing) generated 7% of the country's gross value added (13.9 billion euros), 9.8% of Ireland's merchandise exports and provided 8.5% of national

14. http://www.chambres-agriculture-bretagne.fr
15. https://agriculture.gouv.fr
16. https://www.terra.bzh
17. https://www.teagasc.ie

employment.

The UK is the first trade partner (6.3 billion euros) of Ireland, followed by the USA, Germany and France. Beyond its high trade intensity with the UK, Ireland's specificities make it a unique case in the Brexit context. Due to the strong integration of its production system and supply chains with the UK economy, and the fact that it does not share a land border with other EU countries, Ireland is particularly exposed to a change in UK-EU rules, both for its trade with the UK and with the rest of the EU (Copenhagen Economics, 2018). The UK is the main mean to enter the EU market, for Ireland. This is the so called " *land-bridge*", *i.e.* the road route through the UK, in blue in Figure 3. Maritime transport from Ireland to the rest of the EU is represented in red (and corresponds to the 20h and 38h hours travels).

Both road and maritime transports are options for Irish exports to the mainland EU, but a substantial share of shipments transits the UK by road via the land-bridge since this provides the fastest access route, as presented in the Figure 3. 38% of unitised exports to EU continental ports transit via the UK land-bridge. [18] Longer shipping times (associated with using the sea route instead of the road) increase the cost of transport, especially for highly perishable products. Irish agri-food exports are precisely dominated by perishable products, mainly dairy and meat products, as they account for 61% of total Irish agri-food exports. [19]

As short transport times are of particular importance for those perishable products, the access to the land-bridge route is an important stake for the Irish agri-food trade. Brexit could impact the cost and use of the land-bridge throught additional administrative procedures and then additional time, with direct implications on trade between Ireland and the rest of the EU. We may see an increase in the use of sea transportation for some products, but it is very unlikely that this will become a geneal trend, because of the additional cost of a longer route. For instance, we assume exporters of perishable products are willing to pay a higher transport price to use the land-bridge and save time, instead of switching to the sea longer route and save transport costs.

18. Unitised trade is Roll-on/Roll-off and Load-on/Load-off traffic shipments, https://www.imdo.ie/
19. Comext data for 2015, with author calculation.

Figure 3: Irish exports routes and travel times to the EU

Source: Politico Research
*38 hours at least

4 Problem statement, objective and research questions

First we analyse the effects of Brexit from a global perspective. We highlight the countries most severely affected by this change in trade policy. Next, we focus on the French economy, an important trade partner of the UK and supplier of agricultural and food products, and on Brittany, one of the largest French agri-food regions. Finally, we aim to highlight a particular type of trade costs, having major consequences on bilateral agri-food trade, namely the transport cost. The first chapter discusses Brexit as an example of disintegration, while in the other chapters Brexit is more specifically modelled as an increase in trade costs, through the gravity models. We focus on the bilateral trade between France and Ireland, and the UK land-bridge. In all chapters, we use annual data from 2012 to 2015. [20] The general objective of the thesis is formulated into three broad questions, listed below and addressed in four distinct chapters.

Q1. Is Brexit a first step towards the disintegration of the EU?

The socio-economic and political context broadly evolved over the last years, with major events such as the election of Donald Trump as President of the USA in 2016 and his protectionist ideas, Catalonia's Declaration of Independence in 2017, the rise of populism in some EU countries, and the Brexit vote in 2016. In this context, Brexit can be seen as a particular case of a broader movement of economic and political disintegration, even if we don't know yet where this disintegration trend will stop. In such a context, we wonder

20. This permits to eliminate any bias induced by the global economic slowdown during the 2008 financial crisis and the subsequent recovery, by the dramatic worldwide increases in food prices in the late 2007, or by the announcement of Brexit vote results in mid-2016.

if Brexit is a first step towards the disintegration of the EU. We propose to investigate the following points:

(i) From a methodological point a view, how were the economic integration and dinsintegration addressed in the literature?
(ii) Do we deal with isolated episodes or is it the beginning of a disintegration wave?
(iii) How Brexit may affect the future of the EU, which was longtime a flagship example of deep economic and political integration?

Reviewing the literature, we find that, while integration has been widely studied, disintegration is generally simply conceptualized as the reverse path of integration. Yet, we believe this approach is not satisfying. Moreover, assuming Brexit is the first step of more disintegration, interest in disintegration will increase and the methods for analysing its impacts will improve. We do not know if we really are entering in a new disintegration era, or new political sequence, but we know for sure that Brexit represents a different kind of disintegration than the older ones. The tension emerging from the different levels of governance (national and supra-national levels) appears to be one of the weakness of the EU, and also one of the reasons for Brexit. Will the EU be reinforced or weakened by this event?

Q2. How will Brexit affect the patterns of European agricultural and food trade? Focus on France and Brittany.
We want to assess the impacts of the new EU trade environment throught the example of Brexit and some of the UK's main trade partners, including France. We identify the new challenges faced by European agricultural and food producers after Brexit, and pinpoint the sectors expected to bear the largest effects. In addition to the EU members in general, particular emphasis is attributed to France and one of its regions, namely Brittany.

We study how Brexit will affect the competitiveness of EU members' products on the intra-EU market and main extra-EU markets. The consequences of Brexit are analysed under different scenarios on the outcome of the EU-UK trade negotiations. We use a structural gravity model to predict the potential impacts of Brexit modelled as a change in trade costs, more precisely in the level of UK's and EU's trade. We run the models for both the aggregate agri-food level and distinct product categories. We adapt the structural gravity model for a regional level analysis on the Brittany region.

Our results show that under all scenarios, the losses incurred by the EU as a group and by individual EU countries are considerably smaller than by the UK. The EU is less affected if Brexit is followed by the conclusion of an EU-UK free trade agreement. In case of an exit with no deal, the negative effects on the EU's real income, as well as on EU's global agricultural exports and imports, are attenuated if the UK continues to apply the EU preferential trade agreements with third countries. For both France and Brittany, the models predict sig-

nificant losses in key food categories, namely dairy and cereals for France, and meat, fruit, vegetables and dairy for Brittany.

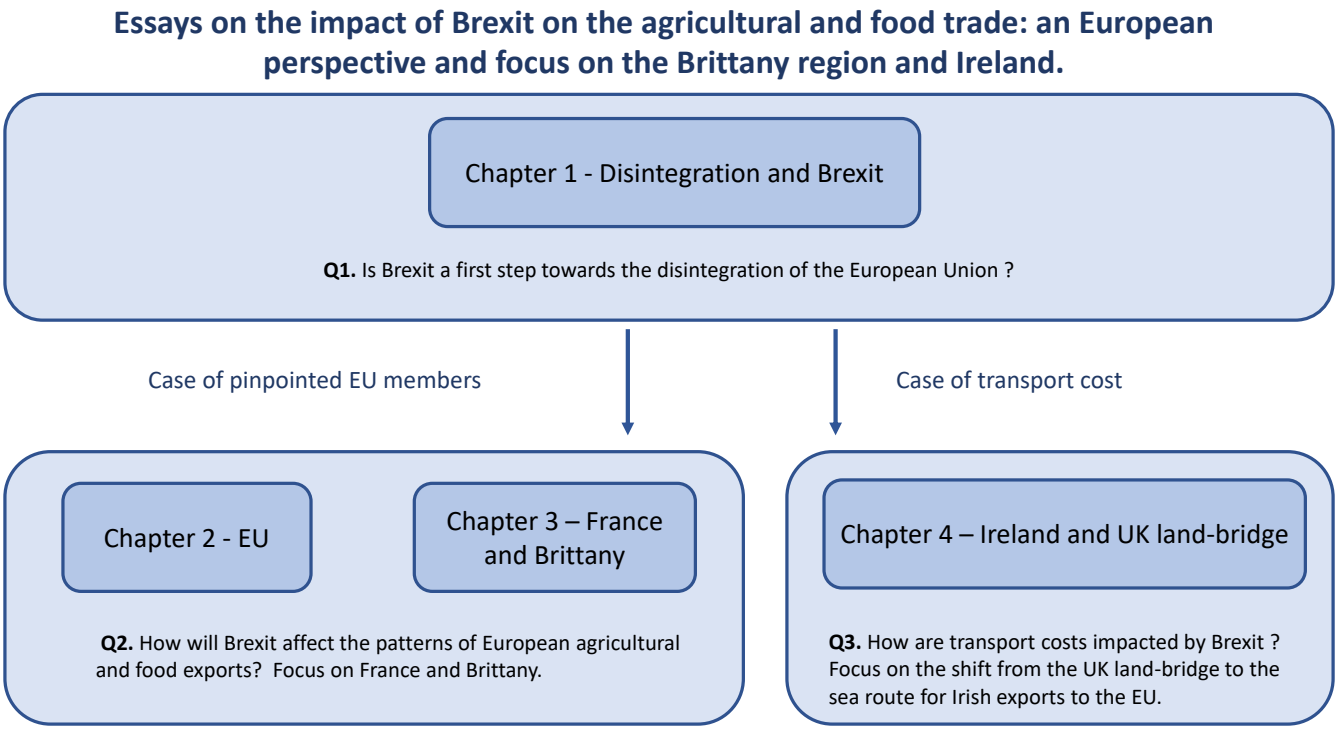
Q3. How are transport costs impacted by Brexit? Focus on the shift from the UK land-bridge to the sea route for Irish exports to the EU.
In addition to tariffs and non-tariff measures, another kind of trade costs is a significant determinant of the bilateral trade flows: the transport costs, usually proxied by the bilateral distance. There are basically two types of transport costs: direct economic shipping costs (such as the fuel) and time costs. The latter are hardly taken into account, as the associated research questions are multiple, *e.g.* the *"just-in-time"* delivery, differentiated impact according to product perishability, *etc*. Yet, time costs are of major importance in agricultural and food sector, given the product characteristics.

Still in the Brexit context and its impact on EU members, we wonder how a change in transport costs can affect trade flows accross Europe, and propose a precise illustration. France and Ireland are major agri-food trade partners. We analyse how Brexit will affect agri-food trade between them, through the induced variation in freight costs. We focus on the different transport modes available to Irish producers to reach France and the rest of the EU, namely the sea route and the road. The latter implies the use of the so called UK land-bridge. We assume that modal shares (road *vs.* sea) will change after Brexit, for the benefit of sea transport, cheaper but longer, if the product is not very sensitive to time cost.

We start by deriving the mode-specific freight costs and modal shares. We find that modal freight costs (road and sea shares) mainly vary in function of the country pair considered, but quite little across product categories. Concerning the modal shares, we confirm that less time-sensitive products present a higher subsitutability between modes. As an illustration of a possible utilisation of the constructed database, we estimate in a traditional gravity framework the trade costs impacts on the trade between Ireland and France, such as transportation costs, in terms of direct shipping costs, but also time costs, in anticipation of potential post-brexit costs variations.

Figure 4 presents the three research questions we aim to address. This PhD thesis comprises four chapters. Chapter I presents a survey on the Brexit as an economic disintegration case (Q1). Chapters II and III present respectively the study of Brexit impacts on the EU and Brittany (Q2). Chapter IV is devoted to the analysis of transport costs' impacts on trade, through the land-bridge example (Q3). This PhD thesis concludes with a general discussion of our results.

Figure 4: Summary of the 3 research questions of the thesis



Source: Author of the thesis

Chapter I

Brexit context and economic disintegration

1 Introduction

Since the beginning of the European Union (EU), the United Kingdom (UK) has had a complicated relationship with the former. It started with two rejected applications, and continued with a tailored accession treaty, the protest of Common Agricultural Policicy (CAP) contribution, the rejection of the Economic and Monetary Union (EMU), and so on. At each step towards a deeper integration, the UK expressed reservations and slowed down the process. This eventful path finally ended with the Britain exit, namely the Brexit. UK's referendum to stay or leave the EU took place in June 2016. A slight majority of British voted to leave. There are many interpretations and meanings of the reasons for such a vote outcome. One of the potential reasons could be the tension between economic benefits and the loss of sovereignty going with the EU membership. Brexit itself occurred on January 31, 2020 but nothing concretely changed yet. The real changes in trade policy are supposed to happen on January 1, 2021. Four years after the vote, many questions on future economic relationships between the UK and its economic partners are still pending. Probable scenarios are emerging, but uncertainty still looms, for both sides, especially about how much economic and political integration would remain between the UK and the EU.

Achieving food self-sufficiency has been a goal since the end of the World War II (WWII) for the European Economic Community (EEC, ancestor of the EU). CAP was created to support the sector and fulfill the objective, even if CAP goals evolved a lot since then. Nowadays, agri-food remains a strategic sector. As an illustration, the EU28 agri-food industry value-added represented in 2015 13.2% of the manufacturing industry value-added.[1] It is therefore not surprising that an important number of papers focus on Brexit impacts on this sector. Many of them attempt to predict the economic impacts on the UK, on the EU27, and to a lesser extent on third countries (*i.e.* non european countries). We review the main studies in the literature treating the Brexit impacts on the UK and the different partners, the type of impacts (*e.g.* on trade, welfare, prices), the methods used, and the trade costs considered in the modeling (*e.g.* tariffs, non-tariff measures (NTMs), depth of the integration *via* trade agreements).

In the literature, Brexit has been considered as a change in trade policy, but also as an example of economic disintegration. Surprinsingly, these past years, Brexit mainly resulted in an increase in academic work about integration, instead of disintegration. To understand why, we investigate the main features of integration and disintegration from an historical, economic but also political point of view, and analyse how the literature traditionally treats disintegration in comparison to integration. We also take the example of the EU as deep integration, and Brexit as the most recent case of disintegration, and analyse how they are

1. https://www.insee.fr

treated in the literature.

Finally, it seems that Brexit could possibly be the first episode of a new disintegration era. Are we entering in a new disintegration era, where Brexit marks the beginning? In other words, what is the future of the EU? To address this question, the debate has to be extended to non-economic fields such as politics and democracy. In particular, the tension between the supra-national *vs.* national governance seems to play a major role in the disintegration cases.

In Section 2 we detail the Brexit context, with the history of the UK's path within the European integration leading to Brexit, the negotiations and the main stakes for post-Brexit agri-food trade. Section 3 proposes a brief literature overview of the Brexit impacts on agri-food sector, and descriptive statistics concerning the EU-UK agri-food trade. Section 4 is devoted to the question of integration process in general, with examples of isolated pre-Brexit cases of disintegration, while Section 5 is focusing on Europe and the illustration of Brexit as a disintegration case. In Section 6 we discuss and conclude.

2 Brexit context: EU membership history of UK, vote and negotiations

2.1 EU-UK history and relationship until 2016

A hard accession of the UK to EEC

In 1951, the European Coal and Steel Community (ECSC) was founded by the Treaty of Paris. The members were West Germany, France, Italy, Belgium, Luxembourg and the Netherlands. The UK declined an invitation to join. The EEC, set up under the Treaty of Rome in 1957 and composed by the same six countries, sought to establish free trade between members. The UK was not a founding member of the EEC, but showed interest in joining the group in the 1960's. The French vetos delayed the membership: President De Gaulle twice opposed to UK membership. The first time was in January 1963. The two countries carried opposite goals and ambitions for Europe. While the French President was afraid that an enlarged community might lead to an Atlantic community dominated by the United States of America (USA), the UK was truly an Atlantic power and wanted to keep its ties with the United States as much as its ties with Europe. Besides, contrary to other members, De Gaulle thought the entry of the UK in EEC would deeply change the nature of the Community as it would evolve towards a large free-trade area. Last but not least, De Gaulle thought Britain was hostile to European integration. In November 1967, despite the positive position of other members, De Gaulle still obstructed the UK membership.

British economic difficulties were advanced to justify this point of view. [2] Finally, the third application was successful. The UK joined the EEC in January 1973, together with Denmark and Ireland.

In addition to the EEC, the 1960's saw the creation of the European Free Trade Association (EFTA), the free-trade area between the UK and six other countries (sometimes referred to as the *"Outer Seven"* by contrast to the *"Inner Six"* or simply *"The Six"* EEC members) that were either unable or unwilling to join the EEC (Sapir, 2012). Originally composed of seven states, EFTA has been later joined by other countries but gradually shrunk, following the successive accessions to the EU of Denmark and the UK (1973), Portugal (1986), and finally Austria, Finland and Sweden (1995).

Should they stay or should they go?

The tensions between the UK and the rest of the community start with the UK Treaty of Accession, in 1972. This is the international agreement which provided for the accession of Denmark, Ireland, and the UK to the European Community in 1973. Trade concessions were granted to the UK, *e.g.* tariff-rate quota (TRQ) for imports from New Zealand. Over the years, other differences emerged. After 1973, Britain economic specificities have led the UK to frequently disagree with the EEC (and later the EU) and refuse some aspects of EEC policy. Historically, the UK has favoured more liberal economic policies than most other EU member states and has opposed strong interventions into the economy. The UK has advocated for limiting transfer of monetary policy and strong intervention in the market mechanisms. We develop two examples: (i) the Economic and Monetary Union (EMU) and (ii) the UK rebate in the CAP. The first referendum on whether the country should continue to be a member of the EU was held in 1975. The UK proposed a referendum to confirm its continuing membership of the EEC, which could be seen as the first Brexit vote, except that the British people voted to stay in by 67%. [3]

(i) In 1978, the European Council establishes the European Monetary System based on a European Currency Unit (the ECU) and the Exchange Rate Mechanism (ERM). The ERM sets for national currencies a central exchange rate against the ECU, and laid the foundation for the later EMU. All the community members apart from the UK joined the ERM. The UK considered that it would benefit the German economy by preventing the Deutsche mark from appreciating, at the expense of the economies of other countries. [4] In 1979, the ERM is launched. Its aim was to harmonise exchange rates across the EEC, in preparation for the adoption of a single currency. Later, the UK will refuse this single currency, namely the

2. https://www.theguardian.com/politics/2016/jun/25/a-timeline-of-britains-eu-membership-in-guardian-reporting
3. http://ukandeu.ac.uk/explainers/factsheet-on-timeline
4. https://www.telegraph.co.uk/news/worldnews/europe/6181087/Timeline-history-of-the-European-Union.html

Euro.

(ii) In 1979, conservative Prime Minister Margaret Thatcher called for the UK's contributions to the EEC to be adjusted, warning that otherwise she would withhold the value-added tax payments. *"I want my money back!"* [5] she exclaimed. The battle lasted four years and finally ended in victory for Thatcher but damaged relations with other member countries: she negotiated a rebate on Britain's contribution to the European Commission's (EC) budget. The EC agreed in June 1984, on the amount of rebate to be granted to the UK. [6]

In 1985, the Schengen Treaty was signed, creating a borderless zone across most of the member states. The UK didn't sign up. Over the years, European countries joined the EU; the Single European Act (1986) and the Maastricht Treaty (1992) were signed, creating the European Single Market and transforming the European Communities into the European Union. EMU was completed in when Euro coins and notes entered circulation for Eurozone States (2002), even if the Euro area was created in January 1999. The Lisbon Treaty was signed in 2007, significantly extending the powers of the European Parliament in the decision making process, and strengthening the European Council.

June 2016: Brexit referendum

Sampson (2017) describes how the UK's adventure in the EU finally ended by the Brexit vote. I sum up thereafter the main features. The 2016 referendum came after a 20-year campaign against UK membership of the EU that started after the Maastricht Treaty (1992). Some parties and politicians argued that sharing political power with the EU was a constraint on UK sovereignty. Particular bones of contention were the UK's commitments to allow free movement of labor within the EU and to accept the jurisdiction of the European Court of Justice.

The turning point has really started when Nigel Farage took over as leader of the United Kingdom Independence Party (UKIP) in 2006 and broadened the party's appeal among working class voters. Under pressure both from supporters of UKIP and from within his increasingly euro-skeptic Conservative Party, Prime Minister David Cameron pledged to hold a referendum on EU membership if the Conservatives won the 2015 general election. Although Cameron supported remaining in the EU, he hoped his proposition would reinforce the right-wing support for the Conservatives and thought that the British would not vote to leave the EU. After the Conservatives won a surprise majority, Cameron's gamble was put to the test. On June 23rd, 2016, 17.4 million people voted to leave the EU and only 16.1 million to remain. Cameron resigned as Prime Minister, and the Conservative Party chose Theresa May to replace him. A long period of negotiations started. Section 4 details

5. EEC Conference, Dublin, November 30, 1979
6. https://www.bbc.com/news/uk-politics-11598879

the hypotheses about the Brexit potential causes (loss of sovereignty, voters characteristics, *etc*).

2.2 2016-2020: negotiations and stakes, from referendum to actual Brexit

2.2.1 UK-EU negotiations

On 29 March 2017 the UK notified its intention to withdraw from the EU and the negotiation process began. Following several rounds of Brexit negotiations, the EU27 and the UK government reached a withdrawal agreement on November 25, 2018. However, the agreement has been rejected three times by the UK Parliament (January 15, March 12 and 29). Theresa May resigned in June 2019 and Boris Johnson was elected as Prime Minister. The text of the treaty [7] was published on 17 October 2019, but the date of exit, initially planned in March 2019, then October 2019, has been delayed once again to January 2020. On 23 January 2020, Parliament of the UK ratified the agreement by passing the Withdrawal Agreement Act. On 29 January 2020, the European Parliament gave its consent to the withdrawal agreement. It was subsequently concluded by the Council of the EU on 30 January 2020. Britain exit finally happened on 31 January 2020.

The UK actually left the EU on January 31, 2020, following the rules of the exit agreement reached by the Prime Minister Boris Johnson and the EU on October 17, 2019. This exit does not include a trade relationship agreement. A transition period is in place until December 31, 2020. During this period the UK must comply with all EU rules and laws. Virtually nothing changed for businesses or for the public. There will be changes after the transition period, whether or not an agreement is reached on the new relationship between the UK and the EU. [8] The future trade relationship between the UK and the EU is still debated, and could end with a *"no-deal"*.

2.2.2 UK-third countries negotiations: trade agreements

During this period, the UK also negotiates agreements with third countries, *i.e.* outside the EU. The EU has to its credit around 40 Free Trade Agreements (FTAs), covering more than 70 countries. As a member of the EU, the UK was not entitled to independently negotiate and sign trade agreements, but could trade with many countries with preferential or even zero tariffs and in the presence of low non-tariff measures, as set by those agreements. Since the Brexit day (January 31, 2020), the UK is free to negotiate and sign new agreements. The UK has signed 20 *"continuity"* agreements covering 50 countries or territories, and around 8% (based on 2018 figures) of total UK trade. [9] The UK has also signed agreements with

7. The Brexit withdrawal agreement, officially titled Agreement on the withdrawal of the United Kingdom of Great Britain and Northern Ireland from the European Union and the European Atomic Energy Community
8. https://www.government.nl/topics/brexit/brexit-where-do-we-stand
9. https://www.gov.uk/guidance

the USA, Australia and New Zealand, but these are *"mutual recognition agreements"* and not FTAs. Mutual recognition makes it possible in particular to improve commercial outlets and to facilitate trade between the signatories. This type of agreement also generates significant savings thanks to accelerated controls and reduced administrative formalities at the time of customs clearance.[10] Trade opportunities seem to be developing between the UK and the USA, but also with the 53 nations of the Commonwealth (including India, Canada, Australia, New Zealand), which represented in 2017 2.4 billion of inhabitants and a gross domestic product (GDP) similar to that of the EU, according to the International Monetary Fund (IMF).

2.2.3 Trade relationship scenarios for EU-UK

Currently, the UK still follows the trade rules as if it was a EU member. Import tariffs between EU members are nil. There is no border control intra-EU28, and the non tariff measures such as the sanitary and phytosanitary (SPS) measures or technical barriers to trade (TBT) are harmonized among the members. What we call *"trade costs"* includes tariffs and divergent NTMs (but not only) and are then quite low in the EU28 zone. The scope of our study includes the changes that might occur in the post-Brexit trade costs. Other aspects, such as foreign direct investment (FDI), free movement of people or labor conditions, are out of the scope. In addition, in the literature, scenarios mainly focus on tariffs and NTMs, instead of other trade costs or trade stakes, such as, for example the TRQs or geographical indications.

In most of the Brexit studies, two extreme scenarios are presented between the EU and the UK, namely soft Brexit *vs.* hard Brexit, while scenarios between the UK and third countries are rarely taken into account. The soft Brexit scenario corresponds to a deep FTA between the EU and the UK (a CETA[11]-like FTA). In the hard scenario, namely the *"no-deal"* scenario, the UK leaves the Single Market and trades with the EU under WTO terms. WTO rules state that the same trading terms must be applied to all WTO members, unless, for example, there is a trade agreement between two or more countries. This is known as most favoured nation (MFN) treatment.[12] MFN means that the UK cannot offer better trading terms to one country and not to WTO members, unless, for example, it has a trade agreement.

Scenarios usually correspond to variations in import tariffs and NTMs. Tariffs are generally set to zero between the UK and the EU for the soft scenario. In the hard scenario, the MFN tariff would apply to bilateral trade between the UK and the EU. Although MFN tariffs are the same across all EU countries, the real level of protection will depend on the trade patterns of each individual trade partner. For instance, a very high tariff imposed on a

10. https://www.douane.gouv.fr
11. Comprehensive Economic and Trade Agreement: Trade agreement between Canada and the EU
12. https://www.gov.uk/guidance

product that is not traded at all is less restrictive than a lower tariff on a much more traded good. As a result, the average MFN duty that the EU could apply to imports from the UK is 18.3% for agricultural and 3.2% for manufactured goods, while EU exports could face respective average tariffs of 14.2% and 2.6%. Agricultural products benefit from a higher MFN protection, which reflects the importance of agri-food as a sensitive sector (Bellora et al., 2017).

Concerning NTMs, there is no consensus about the way to account for them (*e.g.* number, discrepancies between partners). The NTMs cover a diverse set of measures in terms of purpose, legal form and economic effect. NTMs comprise all policy measures other than tariffs and TRQ that have a more or less direct impact on international trade. They can affect the price of traded products, the quantity traded, or both.[13] Many authors point out that costs resulting from NTMs are higher than formal tariffs (Novy, 2013; Looi Kee et al., 2009). In fact, the primary focus of most recent trade negotiations, such as the Canada-EU free trade agreement, has been on reducing NTMs (Dhingra et al., 2017). Concerning potential post-Brexit NTMs between the UK and the EU, in an extreme soft scenario one could infer that NTMs would stay harmonized between the UK and the EU or would differ little. But in the absence of any agreement between the EU and the UK, new NTMs applied by the UK and the EU will probably diverge in the mid-term, accounting for different consumer preferences and trade policies. In a shorter term, procedures will be more complex and longer, because of the end of the common market. In addition, antidumping procedures or other temporary measures could be applied to bilateral trade flows. This will result in NTMs whose trade restrictiveness will increase over time (Bellora et al., 2017). It is difficult to quantify the extent of this increase but it is important to take it into account since NTMs represent a major trade protection. They play a dominant role in restraining imports. A common way of including NTMs in modelling is by estimating ad-valorem equivalents (AVEs) of NTMs, like Looi Kee et al. (2009) did, for each country at the tariff line level. NTMs follow the same general pattern of protection used by European countries through import tariffs, being more restrictive in the case of agricultural goods compared to manufactured products. Bellora et al. (2017) estimate that the EU agricultural exports to the UK face an average NTM trade restrictiveness of 26.01% tariff equivalent (14.37% for industrial goods), slightly higher than those imposed by the EU27 on UK exports (22.78% and 13.37%, for agricultural and manufactured goods, respectively).

An alternative scenario assumes an unilateral liberalization (Davis et al., 2017) of the British market in the spirit of the temporary tariffs the British government intended to introduce in case of no-deal Brexit and announced by the British government in March 2019,[14] and reviewed in May 2020.

13. https://www.oecd.org/trade/topics/non-tariff-measures
14. https://www.gov.uk/government/news/temporary-tariff-regime-for-no-deal-brexit-published

2.2.4 Last updates: new UKGT, COVID-19 and *"Brovid"*

New forecast import tariffs, applicable from January 1, 2021, were announced by the UK on May 19, 2020. This is a *"UK Global Tariff"* or UKGT, which will replace the current common external tariff and will apply to all import products to the UK from countries with which the UK does not have any trade agreements. These tariffs will be lower than the tariffs currently in force. The objective of this UKGT is to facilitate trade with the UK by reducing the administrative burden linked to tariffs. In particular, all tariffs below 2% will be reduced to zero. There are four types of changes: liberalization (tariffs reduced to zero), simplification (tariffs rounded down or truncated), reduction (lowered compared to the current tariffs, but beyond the simplification), currency conversion (conversion of euros in Pound sterlings only). Although, many of the new tariffs would differ from the older, they mainly relate to the non-food sector, and the changes are mostly very small. Indeed, the UK government maintains tariffs on a number of products supporting UK industries such as agriculture, automobiles and fishing. The UKGT will result in the absence of customs duties on 47% of the number of imported products into the UK, in the absence of a trade agreement.

In addition, Britain announced a tariff relief on some goods for tackling with the coronavirus (COVID-19) episode, mainly for medical supplies, equipment and protective garments. This will be reviewed throughout 2020 and will continue to apply in 2021 if necessary. As a consequence, even if the COVID-19 related tariffs changes are not directly applicable to agri-food goods, Brexit and COVID-19 impacts could be, to a certain extent, entangled. British even created a new word: *"Brovid"*. This contraction of Brexit and COVID-19 refers to the possibility of a disastrous temporal conjunction: a second epidemic wave at the end of this year coupled with a lack of a trade deal with the European Union. [15]

2.2.5 Stakes for the EU: focus on agri-food vulnerability

The risks linked to Brexit are several for the EU and highly depend on the outcomes of the negotiations. We first explain why agri-food trade is a strategic and sensitive sector for the EU, then we identify the main three risks for agri-food trade.

Agri-food and CAP

The agri-food sector represents 11% of EU exports to the UK in value. The latter is an important destination for EU exports. The EU has a highly positive agricultural trade balance with the UK (USD 29 billion - average year value over the period 2013 – 2015). According to Bellora et al. (2017), trade protection that could apply on agri-food goods in the absence of a FTA is particularly high (64%, to be compared with 26% before Brexit, taking into accounts both tariffs and NTMs). In addition, agricultural production is managed at the European

15. https://www.standard.co.uk/comment/comment/we-need-to-talk-about-brovid-when-covid-and-a-no-deal-brexit-clash-a4531801.html

level by the CAP (the Common Agricultural Policy of the EU), which benefits from one of the largest European budgets (€ 59 billion per year). Historically, at the very beginning, the European Coal and Steel Community was founded in 1951 and united European countries economically and politically in order to guarantee lasting peace *via* common business interests. Founded in 1957, the EEC aimed to promote free trade between members. As part of building a common market, tariffs on agricultural products had to be removed. To support these measures, and to reach food self-sufficiency, a system of agricultural subsidies was implemented, led by the CAP. It was created in 1962 and represents a large share of the EU budget. It led to a rapid modernization of European agriculture, and to a successful agricultural integration in Europe. This common policy relies partly on UK contributions and constitutes a significant support to EU and UK farmers' revenues. In other words, agriculture and the food industry are an offensive interest for the EU and an important subject for the UK, which depends on agri-food imports from the EU27 (Bellora et al., 2017).

For the time being, the specific modalities of the post-Brexit EU-UK relationship are unknown. In terms of agri-food trade, which is our main focus, the issues and uncertainties are manifold (Bellora et al., 2017). I identify the three main risks below:

- **Direct effect on trade EU-UK**. If the UK becomes a third country without a trade agreement with the EU, not only will the customs controls be re-established for European imports from the UK, but also potentially for European exports to the UK. Likewise, customs clearance costs may increase for certain food products due to the need for additional border controls to ensure compliance with the importer's regulations (the EU or the UK) in terms of food safety and animal health. Customs clearance gives rise to two sources of additional costs: the costs of customs clearance and the delay in clearing the goods. These additional costs can be minimized but not avoided (details in Matthews, 2017b). This increase in trade costs will lead to changes in trade flows, not only between the UK and its partners, but also indirectly between the UK's partners, *via* for example the diversion of flows to the UK to other markets. In addition, the new agreements to be concluded by the UK could reduce the costs of access to the British market for other countries and regions, by further strengthening competition between them and EU products.
- **Increase in EU prices *via* production costs.** In addition to the impacts on exports, the variation in trade costs could impact the price of products imported by the EU agri-food industries. Indeed, certain non-food inputs are part of the intermediate consumption of food production, for example packaging and cardboard boxes. The increase in post-Brexit trade costs could increase the costs of these intermediate products and therefore the production costs of EU food.
- **The Irish border issue and risk of *"trojan horse"* into the EU.** The future status of the border between the two Irelands is one of the key points of the negotiations. The situation in Ulster and the Republic of Ireland is delicate. On the one hand, maintaining a border that is too flexible would be untenable, because Brexit will transform the border

between the two Irelands into an external border of the EU. To exercise no control would be to make Ireland a back door to the EU. We also talk about a *"trojan horse"* which could lead in particular to the import of agricultural raw materials into the EU from third countries with less restrictive health standards, transforming the UK into an import platform. On the other hand, reimposing strict barriers would undermine the fundamental gains of peace and weaken the island's economy. Its recent history is marked by thirty years of civil war, which ended with the Good Friday Agreement in 1998. Since then, the border has become almost invisible. With Brexit and the return of a strict border, new identity disorders could resurface. [16] Both the UK and the EU acknowledging the unique situation of Ireland and Northern Ireland, they agreed that a specific solution was needed to reconcile the different interests at play. This solution was found in the form of the Protocol on Ireland and Northern Ireland from the Withdrawal Agreement, ratified and entered into force on 31 January 2020. [17] This protocol should avoid the return of a physical border to the island of Ireland at the end of the post-Brexit transitional period, and thus minimizes the appearance of conflicts. It allows Northern Ireland to benefit from the single market and, at the same time, remain in the UK customs territory, but if goods transit there before entering the EU, the British authorities will then have to apply EU custom duties. [18] However, the British government announced in May 2020 that, contrary to previous announcements, post-Brexit customs controls will likely be put in place between Great Britain [19] and Northern Ireland for certain goods, especially agri-food, *e.g.* for goods transiting through Northern Ireland with final destination the Great Britain, in addition to the EU. Boris Johnson yet previously insisted there would be no such trade barriers for goods crossing the Irish Sea. This unexpected announcement was not received unanimously by the stakeholders.

The EU and the UK are big partners in agri-food trade, and the current absence of agri-food specific agreement between them makes the preoccupations for the future agri-food trade even more pregnant. In the next section, we present some descriptive statistics, in order to overview the main risks and the most vulnerable products, and we propose a literature review concerning Brexit impacts on EU agri-food sector.

16. https://www.touteleurope.eu
17. This protocol is different from the Irish backstop, proposed by Theresa May and finally abandonned.
18. https://www.capital.fr
19. The names Great Britain (GB) and United Kingdom (UK) are often used interchangeably. However, they are not synonymous. GB is a geographic term referring to the island also known simply as Britain. It's also a political term for the part of the UK made up of England, Scotland, and Wales. UK, on the other hand, is purely a political term: it's the independent country that encompasses all of GB and the region now called Northern Ireland. Source: https://www.britannica.com/story/whats-the-difference-between-great-britain-and-the-united-kingdom.

3 Brexit effects on UK and EU agri-food sector

3.1 Brief literature review

Over the last four years, a number of studies evaluating the economic costs and benefits of Brexit has emerged in the literature using different types of methodological approaches, *e.g.* descriptive evidence or modelling. These works vary not only in their methodological approaches but also in terms of focus (sectors, countries, indicators), scenarios and methodologies. We precise that the Brexit literature is more developed in the next chapters of this thesis.

3.1.1 Sectors, countries and indicators

While few papers focus on the agri-food sector (Van Berkum et al., 2016; Bradley and Hill, 2019; Davis et al., 2017), most papers deal with the impacts on the UK economy in general. Indeed, the stakes for the UK are high: the UK is an open economy with a comparative advantage in services that relies heavily on trade with the EU (Sampson, 2017). Moreover, the UK did decide to exit the EU, hence the majority of papers dealing with Brexit focuses on impacts on the UK. Concerning the effects on the UK agriculture, some studies focus on the impact of Brexit on the British economy, while others place the UK trade partners in the core of the analysis. For example, Bergin et al. (2017), Barrett et al. (2015), and Rojas-Romagosa (2016) analyse the impact of Brexit on the Netherlands and Ireland. Lawless and Morgenroth (2019) discuss the effect of Brexit on EU trade at a sector level. Chen et al. (2018) are interested in the regional level: they study the degree to which the EU regions and countries are exposed to negative trade-related consequences of Brexit. They develop an index of this exposure. They find that UK regions are far more exposed than regions in other countries. Only regions in the Republic of Ireland face exposure levels similar to some UK regions.

Economic consequences of Brexit are considered through different indexes or values in the literature. It may be trade flows, welfare, FDI, GDP, value added or other quantities. For instance, Holobiuc et al. (2018) propose a review of the economic consequences of the UK withdrawal from the EU, in terms of GDP, stocks of FDI, trade in goods and services. HM Treasury (2016b) analyses the effects of Brexit on the UK GDP, and Van Berkum et al. (2016) on the farmers' income levels. Dhingra et al. (2017) are interested in the impact on trade, welfare through consumption, and FDI but not specifically in agri-food. They analyse ten years or more after Brexit (expected to occur in 2019, at the time). Cappariello et al. (2018) focus on the effects on global value chains and Fingleton (2020) on employment.

3.1.2 Methods

Different methodological approaches are used in the Brexit impacts literature. Some authors focus more generally on economic disintegration and consider Brexit as a specific illustration of this process (*e.g.* Sampson, 2017; Larue, 2018). A large number of works evaluate the effects of Brexit using a Computable General Equilibrium Model (CGEM) (*e.g.* HM Treasury, 2016b; Kierzenkowski et al., 2016; Bellora et al., 2017; Erken et al., 2018; Jafari and Britz, 2018; Figus et al., 2018). Some studies assimilate Brexit to the opposite of the EU membership effect and use counterfactual analyses to evaluate its impacts of economic growth, GDP, FDI and trade (Campos et al., 2014; Crafts, 2016; Bruno et al., 2017; Mayer et al., 2019). Born et al. (2019) and Douch et al. (2018) use matching algorithms to construct the counterfactual economic indicators that would have been observed in the absence of the Brexit vote and evaluate the effects on the UK's GDP, consumption, investment, and foreign trade. Some studies are also based on partial equilibrium models like Van Berkum et al. (2018), Davis et al. (2017), or Van Berkum et al. (2016). Finally, Dhingra et al. (2017), Oberhofer and Pfaffermayr (2018) and Bradley and Hill (2019) use a structural gravity approach to estimate the effects of Brexit on trade and welfare.

3.1.3 Scenarios

In most of the studies, two extreme scenarios are presented between the EU and the UK, namely soft Brexit *vs.* hard Brexit, as presented in Section 2.2.3. One usually plays with tariffs but there is no consensus on NTMs treatment. Tariffs are generally set to zero between the UK and the EU for the soft scenario, and to the MFN tariff in the hard scenario. But some authors choose both in-between scenarios and approaches. For instance, Dhingra et al. (2017) assume, for UK-EU: (1) The UK remains part of the Single Market like Norway; or (2) The UK negotiates bilateral agreements with the EU as Switzerland and Canada have done; or (3) The UK and the EU trade takes place on WTO terms. To set NTMs levels for each scenario, they use fractions of tariff equivalents of NTMs between the USA and the EU. While taking correctly into account the NTMs represents a challenge in itself, the work of Dhingra et al. (2017) addressing this issue is detailed in Section 5.1.3.

Scenarios between the UK and third countries can also be either included in these extreme scenarios or out of the scope. For Oberhofer and Pfaffermayr (2018) and Dhingra et al. (2017), in the hard-Brexit, it is assumed that the UK will leave the EU and lose current FTAs with both the EU and third countries. As a consequence, the UK would trade with all countries in the world based on the WTO regulations, EU included. The soft Brexit scenario assumes that all existing trade agreements with third countries are inherited from the EU and remain. Van Berkum et al. (2016) consider a UK-EU FTA, a WTO position but also a UK trade liberalization scenario in which the UK reduces its tariff rates by 50% across the board.

3.1.4 Results in agri-food trade

For the agri-food sector, using different methods, studies find a strong negative impact on the UK economy and a smaller negative effect on the EU, unevenly distributed across member countries. All of these studies find that the most negative outcome would result from the failure of the UK and the EU to negotiate the terms of the UK exit, *i.e.*, if they are unable to strike a trade agreement and apply WTO tariffs to their bilateral trade (Bellora et al., 2017; Bradley and Hill, 2019).

For the UK agriculture and agri-food, Davis et al. (2017) find that the estimated changes are relatively small under the *"FTA with the EU"* scenario. Their projected impacts are larger under the WTO scenario. Besides, they may vary according to the agricultural commodity sectors and depend on whether the UK is a net importer/exporter of the commodities. For the three scenarios considered by Van Berkum et al. (2016) (namely FTA, WTO rules and UK trade liberalization), results under the first two scenarios are rather negative in terms of trade due to higher transaction costs. By contrast, the trade liberalization scenario leads to more openness to trade. In addition, Dhingra et al. (2017) find that, in all scenarios, lower trade due to reduced integration with EU countries is likely to cost the UK economy far more than the gains from lower contributions to the EU budget.

Concerning other countries, Dhingra et al. (2017) study the Brexit impact on both the UK and the UK's partners. They find that the UK experiences the largest welfare losses, but two types of countries other than the UK have relatively high welfare losses: (i) countries for which the UK is an important trade partner, such as Ireland, Netherlands, Belgium, Denmark, Sweden, and Germany and (ii) countries that do not trade much with the UK, but exhibit a negative cross-sectoral correlation between the expenditure share on intermediates sourced from the UK and the trade elasticity: *e.g.* countries such as Hungary, Czech Republic, and Slovakia, which tend to trade more with the UK in sectors with low trade elasticity. In a case of an increase in trade costs between them and the UK, they can't easily substitute towards goods from other countries. Thus, they will have a relatively larger welfare loss as the prices they pay will rise even if they trade relatively less with the UK. They note that the loss of the UK is more than the total loss of other EU countries, both in percentage terms and absolute terms. Finally, countries outside the EU tend to slightly gain from Brexit. This is because of trade diversion effects due to the fact that the UK partially switches from trading with the EU to trading with non-EU countries.

Even if agri-food is a substancial and strategic sector for the EU trade in the Brexit context, studies focusing on the agricultural and agri-food sector are relatively scarce, and essentially, evaluate the impact of Brexit on the British agriculture. In the following we propose, through descriptive statistics, to highlight the vulnerability of the EU agri-food sector, with a focus on France.

3.2 Some stylized facts about EU, France and the context of Brexit

3.2.1 Agri-food: a strategic sector in EU

Agri-food is a strategic sector, as evidenced by high tariffs applied in this sector. Yu et al. (2017) illustrate EU current MFN ad-valorem equivalent tariffs. The numbers, based on the Global Trade Analysis Project database and authors calculation, are averages of the individual tariff lines belonging to each of the 28 product categories considered in their study, weighted by the amount of imports from the main EU MFN trade partners. The EU sectors with the highest levels of protection are sugar (53%), bovine meat (57%), pork and poultry (25%), and milk and dairy (45%).

3.2.2 UK-EU partnership in agri-food trade

In the following, *"agri-food"* refers to products included in the chapters HS 01 to HS 24. See Table A1 in the appendices for the chapter names according to the HS nomenclature (at the 2 digit level). We use data from Comext database [20] for the year before the Brexit vote *i.e.* the year 2015, in the harmonized system (HS) nomenclature.

The UK is an important destination for EU exports. The latter has a highly positive agricultural trade balance with the UK (€ 42.3 billion in favor of the EU). The UK is highly dependent on agri-food imports from the EU, accounting for 69% of the country's total imports in this sector based on 2015 data (€ 55 billion). Figure 1 presents the shares of the UK's agri-food suppliers. France is the UK's third largest foreign supplier of agri-food products, after Netherlands and Ireland. Reciprocally, the EU is a main partner for UK agri-food exports: 65% of UK agri-food exports go to EU countries (€ 12,7 billion).

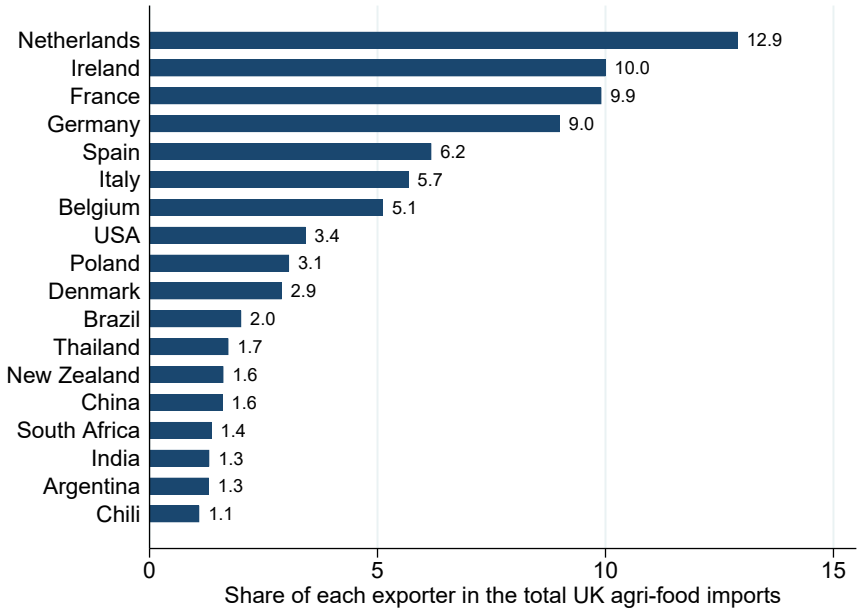
3.2.3 Focus on French agri-food trade and production, and the UK as an important trade partner

In 2014 the EU produced 373 billion euros of raw agricultural product (non-processed). France contributed to 18% of this, with production amounting to 67 billion euros. Overall, France is the largest European agricultural producer, even though this position varies depending on the product. [21]

France is a major agricultural and agri-food producer but also exporter. First employer in the manufacturing industry, with more than 18 000 companies and 380 000 employees, first industry in terms of turnover, the agri-food industry is a major player in the French economy and a vector of competitiveness and attractiveness at the national, European and global levels. [22] Since the end of the 1970's, foreign trade for France has been a surplus

20. Statistics from Eurostat: https://ec.europa.eu/eurostat
21. https://chambres-agriculture.fr
22. https://agriculture.gouv.fr/le-panorama-des-industries-agroalimentaires

Figure 1: Share of each UK provider in the agri-food UK imports, % (2015)



Source: Comext

industry. The agri-food sector is key for French exports. Figure 2 presents the French agri-food main importers classified in function of the proportion they represent, in value, in the French agri-food exports. The British market is the third destination of French agri-food exports, after Germany and Belgium, absorbing 9.4% of France's worldwide exports in this sector. Figure 3 presents the French agri-food exports aggregated by category, in destination to the UK, the EU26, and the rest of the world. The beverages, dairy products and cereal preparation categories constitute the top trio of French exports to the UK. [23] They are also the flagship French exports categories wordwide, together with the meat products.

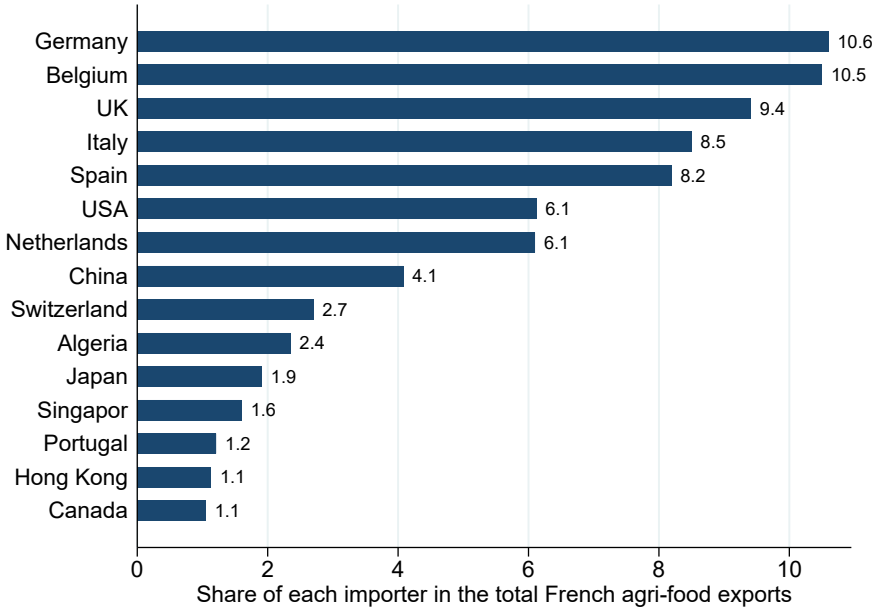
3.2.4 Brexit and the French and European agri-food sector

Figure 4 presents the French dairy products (chapter HS 04) main importers. The classification remains the same than for all agri-food French exports confounded: the UK is the third largest importer (10.2% of total French dairy products exports), behind Germany, and Belgium. The dairy category is an interesting case, because the highly perishable nature of the products makes the distance, time and more generally the transport costs particularly important as trade determinants. Plus, Ireland being another important UK supplier for dairy products, France and Ireland could be in competition for post-Brexit new opportunities. As a result, dairy products represent a interesting stake in the Brexit context.

To sum up, the UK is a net importer of agri-food products and an important destination market for EU agri-food exports. In addition, French exports to the UK are concentrated in few categories, mainly beverages, dairy and cereals. They are therefore particularly

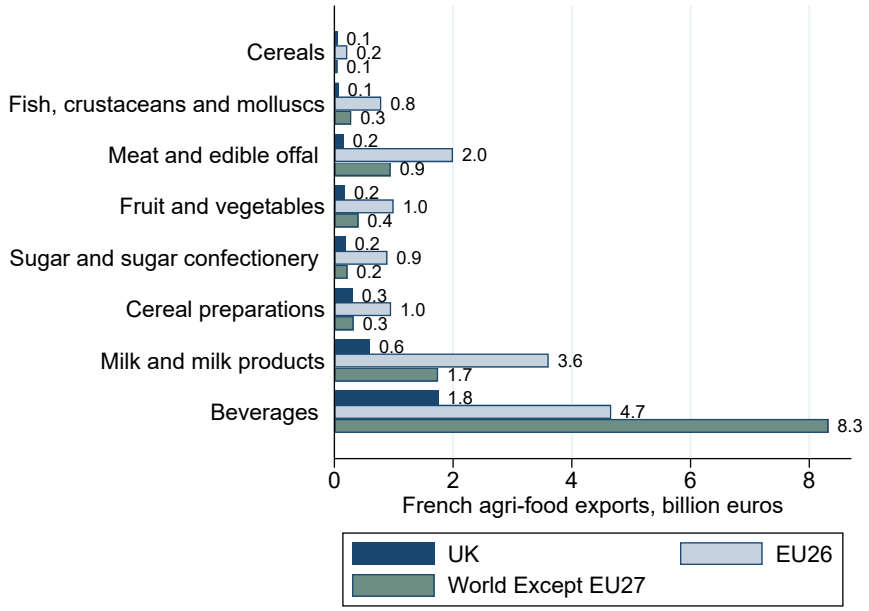
23. Also presented here: https://chambres-agriculture.fr

Figure 2: Share of each destination of the agri-food French exports, % (2015)



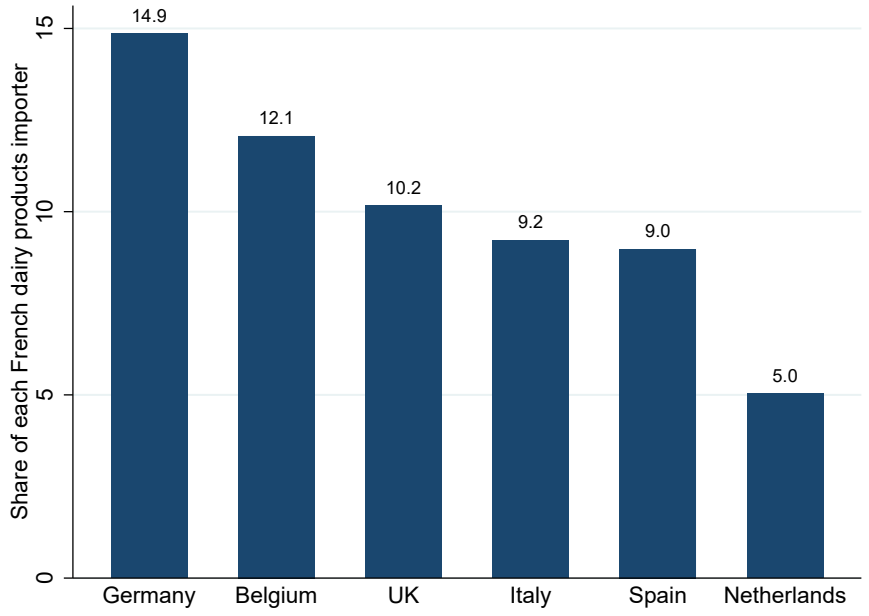
Source: Comext

Figure 3: French agri-food exports (billion euros - 2015)



Source: Comext

Figure 4: Share of each French dairy products importer, % (2015)



Source: Comext

sensitive to policy changes and trade costs increases. These stylized facts suggest that a change in trade policy (post-Brexit, depending on the outcomes of the EU-UK trade negotiations) is likely to have important repercussions on this sector, at both the UK and European levels, as studied in the literature, but also particularly in France.

We have considered Brexit as a change in trade policy. It is also a preminent illustration of economic disintegration. We have seen that the tension between sovereignty and trade interests has always been an issue in the UK, and this is one of the reasons that led to the disintegration. We aim to go up in generality: what do we call integration and disintegration? What are the causes and consequences? Are we entering into a new period of disintegration? We take the EU as an example of deep integration and Brexit as an example of disintegration.

4 Economic integration: definitions, historical approach and evolution

In this section we present the conceptual framework and definitions of economic integration. We focus on trade agreements, such as regional trade agreements (RTAs) and free trade agreements (FTAs) as they are common steps of economic integration. We review the methods allowing to quantify economic integration effects and the influence of the depth of integration.

4.1 Definitions: globalization, levels of integration, trade agreements

Economic integration and globalization

In the economic literature, *"globalization"* is usually defined as the international economic integration of markets in goods, services and capital (*e.g.* in Deardorff, 2014). Yet, economic integration is only one of the aspects of the wider so-called globalization. Indeed, globalization also covers other facets such as cultural homogenization. We consider here the pure economic integration aspect. Supporting Balassa (1961), Sapir (2012) precises that the term *"economic integration"* refers to both a process and a state of affairs. Viewed as a process, it covers *"measures designed to abolish discrimination between economic units belonging to different national states"*; regarded as a state of affairs it is the *"absence of various forms of discrimination between national economies"*. In line with them, we focus exclusively on the former meaning.

Levels of economic integration agreements (EIA)

According to Sapir (2012), Balassa (1961) distinguishes five degrees or stages of integration, still widely used in the literature, also called EIA. They correspond to different types of agreements, allowing different *"levels of integration"*: from shallow to deep. These stages are increasingly demanding in terms of removal of discriminatory measures. **(1)** A free trade agreement (FTA), where tariffs are reduced or eliminated between member countries. **(2)** A customs union (CU), where, in addition, member states establish a common external tariff. **(3)** A common market, where not only trade restrictions but also restrictions on factor movements are reduced or eliminated. In a common market, most trade barriers have been removed between members, with some common policies on product regulation, and freedom of movement of the factors of production and of enterprise and services. **(4)** An economic union, where, in addition to the free circulation of products and factors of production, member states undertake some degree of harmonisation of national economic policies, in order to remove discrimination that was due to disparities in these policies. **(5)** Complete economic integration, which entails the unification of monetary, fiscal, social, and countercyclical policies and the setting-up of a supra-national authority whose decisions are binding for the member states.

Focus on trade agreements

The first step of the economic integration therefore consits in the reduction or elimination of trade restrictions through trade agreements, which are a form of economic integration. We can differentiate them mainly in two types: multilateral trade agreements (MTAs) and regional trade agreements (RTAs).

A MTA settles down among a large set of countries and respects the WTO's MFN principle which states that concessions must apply equally to all WTO members (Larue, 2018). More precisely, the MFN principle establishes that when trading, every WTO member shall

accord the same advantages, favours, privileges or immunities to like products or services of all WTO members. There are nevertheless WTO rules that allow being exempt from the MFN principle. In particular, article XXIV of the General Agreement on Tariffs and Trade (GATT) 1994 permits preferential treatment through the creation of a customs union or a free trade area. [24]

Thereby, in opposition to MTA and the MFN principle, a RTA liberalizes trade among a small number of countries (Larue, 2018). Geographically discriminatory trade policy and departure from the core principle of the multilateral trading system is even the defining characteristic of RTAs (Baldwin and Venables, 1995). Because of this violation of the MFN principle, and the fact that the countries included are treated better than the countries excluded, RTAs are sometimes called *"preferential trade agreements"* (PTAs). In spite of this violation, PTAs are allowed because it is one way to achieve freer trade worldwide (Feenstra and Taylor, 2014). The lowest EIA level is considered to be the FTA, which belongs to the RTAs (or PTAs), formed by reducing or removing tariffs on trade among member nations and leaving members with autonomy in setting their tariffs on trade with non-member countries.

Into the PTAs we distinguish the reciprocal and the non-reciprocal PTAs. We detail below the non-reciprocal. The increase of exports from developing countries to industrialized nations' markets has long been considered an essential element to reduce poverty, promote sustainable development and reap the potential benefits of globalization for the developing world. While there has been an intense debate in policy-making circles on how best to accomplish these aims, the prevailing approach has implied that developed countries give support to the integration of developing countries into the world economy through a *"special and differential treatment"*, in the form of non reciprocal preferences, for imports from the developing world. The leading instrument for such trade preferences has been the generalized system of preferences (GSP), but there exist other non reciprocal preferential trade agreements that are part of this approach. The GSP is an exception to the GATT principles of reciprocity and non discrimination emerged in the second half of the 1960's, through which developed countries provide preferential access to their markets to a large number of developing countries and territories. The European Community was the first to establish a GSP for developing countries and since the early 1970's other developed countries followed its footsteps, such as Japan, Norway, or New Zealand (Gil-Pareja et al., 2014).

From shallow to deep integration

Going from FTA to customs union (stage 1 to 2) constitutes a huge political step. It requires that the participating countries agree to put in place a common trade policy consisting of at least a common external tariff. The fundamental difference between FTA

24. https://unctad.org/en/PublicationsLibrary/dtltlb2011d1_en.pdf

and customs union (CU) resides in the pooling or loss of sovereignty that member countries are willing to accept. Many countries are willing to sign up FTAs but very few are ready to take the extra step of pooling sovereignty over their trade policy, even with their closest trading partners (Balassa, 1961). In addition, between a shallow and a deeper economic integration, the nature of the objectives are not the same. While FTAs are mainly driven by commercial motives, the deepest form (economic unions and complete economic integration) are not simply commercially motivated but also politically driven (Balassa, 1961).

CU and common market can be approached and considered from two different angles. The first is purely commercial and treats CU and common market essentially like FTAs, the emphasis being on the removal of trade barriers between the partners rather than on the existence or not of a common policy among these partners. This trade angle is the subject of the literature on RTAs. The second angle covers broader economic and political matters than simply the removal of barriers. It corresponds to the literature on economic integration, as opposed to trade integration (Balassa, 1961).

More generally, for Bruno et al. (2017) and Campos et al. (2015), shallow integration is epitomized by the free trade area model and is restricted to economic integration, while deep integration combines economic and political aspects. Complete integration involves a political union with a supra-national authority. After complete economic integration, the integrated units have no or negligible control of economic policy, including full monetary union and complete or near-complete fiscal policy harmonisation. [25]

To sum up, the economic integration refers to the various types of agreements coordinating economic policies and regulations between countries. From shallow to deep economic integration, it seems that the deepest are accompanied by supranational forms of governance, and delegation of the decision-making responsibility.

4.2 Economic integration impacts assessment

Methods

Several quantitative methods are available to assess or quantify the integration effects, and more generally the effects of changes in bilateral trade costs due to a change in trade policy. The most commonly used are the gravity models and the computable general equilibrium models (CGEMs). Studies are mainly interested in the effects in terms of welfare for the members and the rest of the world, through different channels, *e.g.* trade volume or value, products variety, level of income, or FDI.

25. Total economic integration implies the pursuit of a common economic policy by the political units involved. Examples are the cantons of the Swiss Confederation. https://www.britannica.com/topic/international-trade/Economic-integration:

Gravity equations enable to estimate the trade integration gains and have come to maturity recently (Mayer et al., 2019). While the former have been estimated since the early sixties, the widespread use of structural gravity models in the field of international trade is a fairly recent phenomenon. Before the micro-theoretical foundations of gravity, Krugman (1995) and Leamer and Levinsohn (1995) argued that the lack of a good analysis of multilateral trade in the presence of trade costs was major gap in trade theory, and that the gravity models were strictly descriptive (Costinot and Rodríguez-Clare, 2014). But the times have changed recently. The last decades have seen an explosion of alternative micro-theoretical foundations underlying gravity equations (see Eaton and Kortum, 2002; Anderson and Van Wincoop, 2003; Bernard et al., 2003; Chaney, 2008; Eaton et al., 2011). While new gravity models encompass a large number of market structures, from perfect competition to monopolistic competition with firm-level heterogeneity *à la* Melitz (2003), and a wide range of micro-level predictions, they share the same macro-level predictions regarding the structure of bilateral trade flows as a function of bilateral costs.

Results

In the literature, authors generally conclude that globalization not only generates economic growth, but also has non-economic benefits (Frankel, 2000). Globalization effects are assessed on various indicators and via different channels. We present examples.

First, Baldwin and Venables (1995) detail the three types of economic effects of RTAs and economic integration (namely allocation effects, accumulation effects, and location effects) and conclude that RTAs seem to have generated welfare gains for the participants, with small, but possibly negative spillovers onto the rest of the world. Second, according to Feenstra (2018), the monopolistic competition model in international trade offers three sources of gains from trade beyond that of traditional comparative advantage: an endogenous expansion in product variety; a pro-competitive reduction in the markups charged by firms; and the self-selection of more efficient firms into exporting. He demonstrates the empirical importance of the first two in the increase in the US welfare by using a bounded Pareto distribution for productivity. Third, Graziano et al. (2018) are interested in the effect on uncertainty. They find that the trade agreements lower the uncertainty due to trade policy, which increases the FDI. Finally, in line with them, Baier and Bergstrand (2007) confirm that FTAs do increase members' international trade.

The negative impacts of integration are hardly studied. Some recent papers address this subject. For example, it is commonly accepted that international trade brings more varieties of products to the consumers, which generates gains from variety of products available to consumers, but some papers moderate this idea, *e.g.* Morgan et al. (2020) who show that the enhancement of trade can leave both countries strictly worse off.

Influence of the depth of integration

More than integration itself, is integration depth a determinant of the amplitude and kind of impacts? Studies suggest that the deeper the integration, the higher the positive economic effects. For instance, according to Mattoo et al. (2017), deep agreements lead to more trade creation and less trade diversion than shallow agreements. Marković and Đokić (2018) explain that a deeper integration increases competition, and therefore also the productivity, economic growth and welfare. Measuring the *"depth"* based on the number of provisions the agreements cover, Mulabdic et al. (2017) find that deep trade agreements increase goods and services trade by 42%, and value-added trade by 14% on average. Baier et al. (2014) find that deeper EIAs have larger trade effects than FTAs, and the latter have larger effects than two-way and one-way PTAs.

It has been recognized, at least since Balassa's seminal work (Balassa, 1961), that the relationship between political and economic dimensions of regional integration is a key point. For this reason, Campos et al. (2015) argue that deep (joint economic and political) integration is associated with significantly larger and longer-lasting benefits than shallow (purely economic) integration. They estimate the benefits from economic integration that are generated by political factors and by the complementarity between economics and politics. They call these the political economy benefits from regional integration and provide evidence that these net politically-driven economic benefits from integration exist and that they are non trivial.

In the next section we present an historical summary of the evolution of the economic integration with a focus on the last decades. We highlight some disintegration episodes among the global increasing integration and analyse how they have been treated in the pre-Brexit literature.

4.3 Global economic integration evolution in the pre-Brexit history, and some cases of disintegration

Historical summary of the integration process

Global economic integration is not a new phenomenon. For example, in the 15th century, Christopher Colombus initiated an important era of integration and all new trade routes. Let us jump to the 19th century. We can distinguish two *"waves of globalization"* in the modern history: the first started in the 19th century, the second one after the WWII (1939-1945). In a seminal paper, Jacks et al. (2008) propose a micro-founded measure of aggregate trade costs, based on gravity equations. With the former, they examine the drivers of the growth of global trade between 1870 and 1913, its retreat from 1921 to 1939, and its subsequent rise from 1950 to 2000.

The **first wave** of globalization was marked by the rise and collapse of intra-European trade. From about 1870 and until World War I (WWI, 1914-1918), a high integration of national and international commodity markets occured, and has been addressed by numerous studies along several dimensions (*e.g.* discussion about price convergence or divergence in Hynes et al., 2012). In particular, a trade boom occurred between 1870 and 1913, 55% explained by the trade cost declines (Jacks et al., 2008).[26] The first wave is characterized by inter-industry trade. This means that countries exported goods that were very different to what they imported. For instance, England exchanged machines for Australian wool and Indian tea. This wave is followed by a dramatic disintegration, during WWI, a timid and gradual reintegration during the 1920's, and a substantial disintegration after 1929. The period saw the unravelling of many of the integration gains of 1870–1913 (Hynes et al., 2012; Milanovic, 2002). The era 1918-1940 is the so-called **interwar period**. Jacks et al. (2008) find that a precipitous rise in trade costs explains the entire interwar trade bust. After the interwar disintegration episode, from 1950, a vast movement of deep integration emerged, namely the **second wave** of globalization. The post war integration, from 1945, has been particularly fast. Over the period 1950–2004, world trade grew at a rapid average rate of 5.9% per annum (Hummels, 2007). Economic globalization is one of the most powerful forces to have shaped the post-war world (Frankel, 2000).

This second wave was enabled by different drivers. One prominent possible explanation for the rise in international trade is a decline in international transportation and communciation costs (Hummels, 2007), *i.e.* a technology improvement. The world-wide expansion of trade after the WWII was largely possible because of reductions in transaction costs stemming from these technological advances, such as the development of commercial civil aviation, the improvement of productivity in the merchant marines, and the democratization of the telephone as the main mode of communication.[27] Specifically, the introduction of containerized shipping is thought by many specialists to be one of the most important transportation revolutions in the 20th century (Hummels, 2007).

Yet, Jacks et al. (2008) find that trade cost decline explains roughly 33% of the post–WWII trade boom (againt 55% for the first wave). Other drivers have grown in importance, such as the support from public policies (Frankel, 2000). Drivers being different in comparison to the first wave (inter-industry trade), the second wave is characterized by a rise in intra-industry trade (*i.e.* the exchange of broadly similar goods and services is becoming more and more common).

Concerning the public policies support, we develop here the example of the GATT. After the WWII, the GATT was created (1947) and intended to boost economic recovery after WWII

26. International trade costs are the costs of transaction and transport associated with the exchange of goods across national borders and, thus, impede international economic integration (Jacks et al., 2008).
27. https://ourworldindata.org

through reconstructing and liberalizing global trade. It aimed to create rules for a global trading system that would bind countries in peaceful commercial relations. It is a legal agreement between many countries, whose overall purpose was to promote international trade by reducing or eliminating trade barriers such as tariffs or quotas. During the GATT years, eight rounds of tariff negotiations were held between 1947 and 1994. The GATT gradually lowered tariffs and strengthen trade rules until its replacement by the WTO on 1 January, 1995. In parallel, the creation of the GATT did not diminish the attraction of bilateral or regional approaches to international trade relations. On the contrary, the push for new regional agreements, especially in Europe, re-emerged less than five years after the GATT was launched, ushering in a long period of creative tension between regionalism and multilateralism, and paving the way for dramatic advances in both approaches. The last decades have witnessed phases of regionalism, driven, at least in part, by a perceived need among groups of countries to go *"further and faster"* than the broader GATT system in order to manage *"deeper"* trade integration. Although the widening and deepening of the EU has been at the centre of each successive wave of regionalism, North America and now Asia have also joined the race. [28] As a result, RTAs and MTAs, as integration enhancers, developped a lot during the second wave of globalization, punctuated by isolated cases of economic disintegration. We present in the next section some EU pre-Brexit disintegration episodes.

Disintegration episodes in the pre-Brexit literature

Episodes of disintegration were analysed by economists mostly from different perspective, in function of their nature. Old cases of disintegration include the end of the British colonial empire, the breakup of the Austro-Hungarian empire (De Ménil and Maurel, 1994), or the Ottoman Empire fall. These cases have been studied from an historical perpective. In addition, the interwar economic disintegration of the commodity market interrupted the economic development and integration and has been widely documented (*e.g.* Hynes et al., 2012). In addition, a trade war occurred in the 1920's and 1930's between the Weimar Republic and Poland, in the German–Polish customs war. A trade war is an economic conflict resulting from extreme protectionism in which states raise or create tariffs or other trade barriers against each other in response to trade barriers created by the other party. Finally, few isolated cases of disintegration took place after the WWII: Maurel and Cheikbossian (1998); Djankov and Freund (2002); Fidrmuc and Fidrmuc (2003) study the collapse of the Soviet Union (USSR), the dissolution of Yugoslavia and of Czechoslovakia, which correspond to changes in economic system. Concerning the methdology, Fidrmuc and Fidrmuc (2000) and Fidrmuc and Fidrmuc (2003) use gravity models to assess the economic consequences of new borders in Eastern Europe, specially on trade intensity. They find that disintegration has been followed by a sharp fall in trade intensity between the constituent parts of Czechoslovakia, Soviet Union and the Baltics. But the trade liberalization between East and West has led to gradual normalization of trade relations,

28. https://www.wto.org/english/res_e/booksp_e/anrep_e/wtr11-2b_e.pdf

and the EU integration has reversed the fall in trade intensity among Central European countries. One of the causes of such disintegrations was a political identity crisis and the resurgence of nationalism in the Soviet Union and Central and Eastern Europe. While nationalist politics play a significant role, ethnic mobilization has reached unprecedented levels in multinational Communist states (Vujacic and Zaslavsky, 1991).

With the recent souring of relations between China and the USA, the notion of trade wars is no longer consigned to academic treatments of the interwar period (Jacks and Novy, 2020). Indeed, more recently, the President of the USA Donald Trump's trade wars have been and still are the object of numerous studies, *e.g.* Fetzer and Schwarz (2019). Trade disputes are very common place. WTO lists 316 GATT disputes from 1948 to 1995. Yet, few disputes reach a stage of escalation in which threatened tariffs are actually imposed or retaliation measures are triggered (Fetzer and Schwarz, 2019). A markable exception is the recent trade escalation provoked by the US administration under President Donald Trump starting in March 2018. He announced on 2018 that the US would impose a 25% tariff on steel and a 10% tariff on aluminium imports. Additionally, the Trump administration set a tariff of 25% on 818 categories of goods imported from China worth $ 50 billion. Some of the targeted countries reciprocated with tariffs of their own targeting imports from the US many of which started to take effect from July 2018 onwards.

Closer to us, in the EU, Brexit marks a downturn in the relatively recent history of increased integration and globalization that has characterized the past seven decades. We focus on the EU example of deep integration and Brexit illustration as a disintegration. We also focus on the methods assessing disintegration in the Brexit case.

5 From European deep integration to Brexit disintegration, and beyond?

The economic literature abounds with studies on economic integration, a large number of them focusing on integration within Europe. Episodes of disintegration were analysed by economists mostly from a historical perspective, or from that of a change in economic system as evoked in Section 4.3. In this context, Brexit comes as an unprecedented example of economic disintegration among a growing integration and globalization.

5.1 Focus on integration and disintegration in Europe

5.1.1 The European Union: an illustration of a deep form of integration

Deep integration

The EU has been a precursor of deep integration. Mulabdic et al. (2017) build a measure of *"depth"* based on the number of provisions covered by the agreement and show the EU

is the deepest PTA among the 279 currently in force. The relationship between the EU members is regulated by the European Community Treaty and the following enlargement agreements, which cover 44 policy areas ranging from standards to movements of capital, to labor mobility. Europe is also the region that has the largest share of intra-regional trade. In addition, the EU provides an intense network of trade relations and a deep integration of each member in regional value chains. The EU Customs Union and Single Market are the marks of a deep integration (economic and political), compared to a shallow integration (purely economic).

EU integration effects

The EU integration impacts have been widely assessed, using different methods usually employed for the integration effects quantification, and focusing on different economic channels, *e.g.* FDI, trade and welfare. Bruno et al. (2017) estimate that the impact of EU membership on trade and FDI are substantial: *e.g.* the EU membership increases FDI inflows by on average 28%. Mayer et al. (2019) estimate the economic gains from European integration through the trade channel: all member countries unambiguously obtain sizable welfare gains from the EU as it is. They provide quantified evidence of the welfare brought by the EU to the population of member countries, which is also the *"costs of non-Europe"*, weighted by country size. These costs are estimated to vary between 2% and 8% depending on the counterfactual (RTA *vs.* return to WTO rules). Other dimensions of European integration matter and can be assessed, such as the free mobility of capital and labor or the effects of the euro. Campos et al. (2015) estimate the benefits from economic integration generated by political factors and by the complementarity between economics and politics, disantangling the economic from political determinants. They take the example of Norway, which ended up being fully economically integrated with the EU but not politically integrated. In addition, policies supporting integration, such as low taxes, flexible labor legislation, deregulation, privatization, and openness are pursued by governments in order to earn market confidence and attract trade and capital inflows (Rodrik, 2000).

Integration also provides non-economic gains (or losses), political stability being probably the most important of those. Martin et al. (2012), and Vicard (2012) emphasize the security gains associated with regional trade integration (Mayer et al., 2019). Concerning migration, Simionescu (2018) assesses the impact of European economic integration on migration in the EU15, from the newly integrated EU countries (*cf.* the recent enlargement of the EU, since 2004). In the 2000-2015 period, the number of migrants from the new member states of the EU has increased, in average, with more than 2200 people only due to their EU membership. This result reflects the positive impact of European economic integration on the number of emigrants from the Central and Eastern Europe countries that chose the EU15 states as destination countries. Finally, according to Lavery et al. (2019), Brexit created an opportunity for alternative European financial centres, and the corresponding economic benefits, in the aftermath of Brexit. Significant business functions are likely to leave the

City of London and relocate to inside the Eurozone, Frankfurt and Paris being two of the main *"rivals"* to the City of London.

5.1.2 From a deep integration to Brexit

Economic gains brought by the EU to all members are indisputable. The UK economy is part of the intense network of trade relations forged over the years by the EU, which has brought several advantages. At present, the EU is the most important trade partner of the UK, accounting for 52% of the UK's exports of goods and services. In addition, the UK is closely integrated in regional value chains. For instance, the share of intermediate value added on total domestic value added in UK exports (the majority of which goes to the EU) is close to 70% (Mulabdic et al., 2017).

From a more historical point of view, some studies are interested in the gains from the EU accession, with respect to the UK's situation before joining the EC (and later the EU). For instance, Gasiorek et al. (2002) provide a decomposition of the welfare impact on the UK arising from the changes in manufacturing trade consequent upon joining the EC, with a CGEM of manufacturing trade incorporating imperfect competition and firms' specific increasing returns to scale to study the accession of the UK to the EC in the early 1970's. The results suggest that gains from European integration come less from the traditional theory of integration (trade creation and trade diversion) and more from imperfectly competitive approaches to trade theory which emphasize economies of scale, and the impact on the competitive environment. While the welfare impact could indeed be relatively small, this depends on the extent to which the process of integration leads to changes in competitive interaction. The greater the pro-competitive impact of integration, the higher are the potential welfare gains.

To balance this consideration, we remind that the UK was not part of the Economic and Monetary Union (EMU), and Rose and Engel (2000) find that members of currency unions are more integrated than countries with their own currency. Currency union members have more trade and less volatile exchange rates than countries with their own currency. As a result, it seems that the UK did not benefit from these positive effects, contrary to the fully integrated EU members.

But in spite of the global benefits brought by the EU to all members, including the UK, it finally ended with the Britain exit. Even if the existence of the EU27 is not called into question nowadays, Brexit represents a case of disintegration in the sense that the economic agreement between the EU and the UK is coming undone. While one of the big questions related to Brexit concerns a potential trade agreement between the EU and the UK, or an absence of it, Brexit is more than about trade.

5.1.3 Brexit literature as a disintegration case

Over the last four years, a number of studies evaluating the economic costs and benefits of Brexit have emerged in the literature using different types of methodological approaches. I proposed in Section 3.1 of the present paper a Brexit review focusing on Brexit as a shock, changing trade policies and increasing trade costs, on agri-food sector. To sum up, we highlight that a large number of works evaluate the effects of Brexit using a computable general equilibrium model (*e.g.* Bellora et al., 2017; OECD, 2016; Jafari and Britz, 2018; Figus et al., 2018) or structural gravity models (*e.g.* Dhingra et al., 2017; Oberhofer and Pfaffermayr, 2018).

In this section we are more interested in the positioning of the method of disintegration impacts assessment in comparison to integration, considering Brexit as a specific illustration of disintegration. From this perspective, we notice that some recent papers are located at the crossroads of two strands of economic literature: the literature that investigates the impact of trade agreements on members' trade relations, and the recent literature that focuses on the economic and trade effects of Brexit, such as Mayer et al. (2019); Mulabdic et al. (2017); Campos et al. (2014); Crafts (2016); Bruno et al. (2017); Mayer et al. (2019). Mayer et al. (2019) revisit the gains the EU has reaped from trade integration since 1957 and what would be the costs of going backwards (*i.e.* the cost of non-Europe). Mulabdic et al. (2017) wonder what would be the impact of undoing trade agreements on trade. They address this question by focusing on the effect the EU membership had on the UK trade, most notably with its European partners, and then use this information to assess the future of UK-EU trade under different scenarios. They find that EU membership had a strong impact on UK-EU trade and that it contributed particularly to the rise of UK services exports and its integration in global value chains. They then analyse the impact that changes in the UK-EU trade agreement can have on UK-EU trade relations going forwards. They consider distinct scenarios, with decreasing depth of the future agreement between the UK and the rest of the EU. They find that there is a clear trade-off between the depth of such agreement and the intensity of future UK-EU trade. In particular, a shallower agreement will have a stronger negative impact on the UK's services trade and global value chain integration, which have relied more on the deep arrangements of the EU.

In this new strand, the main methods used consist in quantifying the effects of EU integration in order to evaluate what would be the cost of non Europe, or of a step backwards in integration. The idea is to assimilate the effect of Brexit to the opposite of the EU membership effect, and use counterfactual analysis to evaluate its impacts of economic growth, GDP, FDI, and trade. Basically, the same methods are used for both integration and disintegration, playing with the increase or decrease of trade costs or the depth of integration. We find this trend even in a linguistic approach: the word *"disintegration"*

is rarely used. In the appendices I present an Econlit [29] occurence research of the words *"integration"* and *"disintegration"* showing the relatively low occurrence of the latter, compared to the first, over the years. This analysis is in line with Sampson (2017) which reviews the literature of the potential economic consequences of Brexit. According to him, researchers have used three approaches to estimate the effects of Brexit: (1) historical case studies of the economic consequences of joining the EU; (2) simulations of Brexit using computational general equilibrium trade models, and (3) reduced-form evidence based on estimates of how EU membership affects trade.

Yet, a disintegration is not totally equivalent to an integration unraveling. Let's take the example of NTMs. It is highly unlikely that the UK will return to the same level of NTMs than before joining the EU. Now they are harmonized, a high divergence would cost too much. The way Dhingra et al. (2017) address NTMs issues is a good illustration. They use information provided by Berden et al. (2009): the NTMs level between the EU and the USA, but also the fraction of these NTMs that is reducible for each sector, *i.e.* the fraction of the trade cost that could in principle be eliminated by policy action. [30] As it is unlikely that the UK will face the same NTMs as the USA following Brexit, in the soft Brexit scenario they assume the UK faces one-quarter (1/4) of the reducible NTMs faced by the USA, while in the hard Brexit scenario they assume UK-EU trade is subject to three-quarters (3/4) of the reducible NTMs. Brexit is not seen as the exact reverse of the EU.

Even since the Brexit vote, interest in disintegration, or integration unraveling (*i.e.* reverse of integration) has been more limited than in integration itself. Campos et al. (2014) even say that one of the few undisputed benefits from Brexit is that it motivated a huge amount of new research on the political economy of deep integration. Yet, we live in an age where it seems that the most likely outcome in the near future might be one of trade disintegration in Europe, possibly reversing one of the deepest and most prolonged trade liberalization process in modern history. The choice of the UK to exit the EU, combined with the calls from many governments for a reversal of key integration agreements like Schengen, can lead to more disintegration in the future (Mayer et al., 2019). These observations suggest that disintegration will be the subject of some studies and interests in the near future. One of the positive spillover effects could be the developement of new research on disintegration effects, regardless of integration, and using new methods.

In the following, we aim to highlight the mechanisms: why did Brexit happen? Why could it be the sign of a new disintegration wave? In other words, what does Brexit mean for the future of the EU and, more broadly, global economic integration?

29. https://www.aeaweb.org/econlit/
30. The authors calculate detailed tariff equivalents of non-tariff barriers between the USA and the EU, using econometric techniques and business surveys.

5.2 A new wave of disintegration?

In this section we analyse and highlight some potential causes of the most recent disintegration, namely the Brexit. In addition, we wonder and analyse whether we are entering in a new disintegration era (new political sequence), whose Brexit marks the beginning.

5.2.1 Brexit causes

Globalization and disintegration are topics at the crossroads of several fields. Many questions have been raised, in different research areas, such as economics, politics, sociology. In particular, economic integration appears to be closely linked to politics, and can have impacts on other fields such as democracy or sovereignty. For instance, a branch of literature focus on public opinion and support (or non support) for EU integration. According to Hobolt and De Vries (2016), older studies such as Gabel and Palmer (1995); Inglehart (1970); Sánchez-Cuenca (2000) focus on support for European integration whereas the focus in the last decade has shifted to opposition to European integration, or so-called Euroskepticism, *e.g.*, Hakhverdian et al. (2013); Hooghe (2007); Leconte (2010).

In the case of EU and UK, a deep (political) integration has led to a disintegration, namely the Brexit. According to Sampson (2017), support for Brexit came from less educated, older, less economically successful and more socially conservative voters who oppose immigration and feel left-behind by modern life. With the referendum the debate was about whether the UK should prioritize remaining economically integrated with the EU or taking control of immigration and economic regulation. Integration lost. Why? Is it possible to extract the elements that led to this end? We try here to better understand the causes, or hypotheses of causes. More broadly, Brexit raises questions about the future stability of the EU and the future of the globalization.

Sampson (2017) details the reasons of the voters, and the categories of voters supporting Brexit. In addition, he resumed the three factors affecting support for European integration from Hobolt and De Vries (2016): economic cost–benefit calculations; values and identity; and the information available to voters. Sampson (2017) excludes the first hypothesis and concludes that both the values and identity, and the information available to voters could have played a role, leading to two hypotheses (below) and therefore two paths of political implications for the future of EU. We detail these two hypotheses, evoke other general causes of disintegration and wonder what is the future of the EU.

Hypothesis 1: primacy of the nation-state

Successful democratic government requires the consent and participation of the governed. British people identify as citizens of the UK, not citizens of the EU. Consequently, they feel that the UK should be governed as a sovereign nation-state. EU membership erodes Britain's sovereignty. In particular, it prevents the UK from controlling immigration and

forces the UK to implement laws made by the EU. According to this hypothesis, British people voted to leave the EU because they wanted to take back control of their borders and their country. In addition, the unprecedented development in supranational governance has led to greater public contestation of the European Union.

The nation-state hypothesis is closely related to Rodrik (2000)'s idea (also included in Rodrik, 2011) that the global economy faces a political trilemma: Rodrik (2000) argues that nation-states, democratic politics, and deep international economic integration are mutually incompatible, and that countries can choose at most two of the three options. Viewed through this framework, the nation-state hypothesis sees the Brexit vote as a democratic response to the erosion of British sovereignty caused by EU membership. If this perspective is correct, it means the deep integration promoted by the EU is incompatible with national democracy as in the UK. For the EU to remain democratic, either the people of the EU must develop a collective identity in place of their separate national identities, or the supranational powers of the EU must be reduced. Otherwise, the tensions evident in the Brexit vote will recur in other countries and the EU may lose more members. Details of the trilemma problem are presented in the appendices.

This hypothesis highlights the general conflict between political integration and sovereignty. For example, in social sciences, Guillén (2001) raises a key debate about globalization, and questions if globalization undermines the authority of nation-states. Margalit (2012) explains the sources of popular discontents and opposition to economic globalization. Among them, non-economic sentiments such as nationalism and ethnocentrism. Many individuals fear, beyond the economic consequences of trade openness, what they perceive to be its social and cultural consequences.

Hypothesis 2: scapegoating of the EU

Many people in th UK feel left-behind by modern Britain. The left-behind are older, less educated, more socially conservative, less economically successful and think life in Britain is getting worse. Since the global financial crisis, the UK median wage has declined (Costa and Machin, 2017). Influenced by the anti-EU sentiments expressed by Britain's newspapers and eurosceptic politicians, these individuals have come to blame immigration and the EU for many of their woes. According to this hypothesis, voters supported Brexit because they believed EU membership has contributed to their discontent with the *status quo*.

Going in the same direction, Larue (2018) wonders why is economic integration a hard sell. The big idea is that misleading cues are spreading to manipulate public opinion. He relies on Kahneman (2011)'s work to argue that the average person is a poor statistician, relying on mental shortcuts rather than thinking things through. Based on West et al. (2002)'s paper, he also argues that people can simultaneously hold very strong opinions while

knowing very little. As a result, opinions can be manipulated by distorting facts, providing misleading statistics, and citing commissioned studies for pseudo external validation. He gives the example of support for high tariffs, which has been secured by appealing to various sentiments such as national pride (domestic is always better than foreign), social justice (pitting small domestic farms and firms against large foreign farms and multinationals), and fair play (foreign suppliers have better technologies or are subsidized).

Finally, another part of the literature treats the weak link between trade policy preferences and the personal interests of individuals (Rho and Tomz, 2017), or the preference for protectionism, or the fact that people are protective of their beliefs and avoid sources of information that could challenge their beliefs (Bénabou and Tirole, 2016), but they are out of our scope.

5.2.2 Other general and theoretical causes of disintegration: nation-size in a liberalized and heterogeneous zone

Alesina et al. (2000) argue that trade openness and political separatism go hand in hand. Economic integration would then lead to political disintegration. The reason is that, in a liberalized zone, the external markets access matters more than the domestic market. As a result, country size is no longer important for the trade. In this context, the cost of population heterogeneity can become superior to the benefit of the domestic market size. This is how smaller nations can emerge, until reaching an equilibrium number of countries. Thereby, trade liberalization (integration) and average country size are inversely related and the process of nation-building can then be interpreted as resulting from the trade-off between the benefits of market size and the costs of population heterogeneity.

In the Brexit case, over the years, heterogeneity between EU members increased, with te accession of poorer countries, aggravated by the migration from outside the EU. Considering the EU as a big nation, the trade-off between the benefits of the EU market for the UK and the costs of population heterogeneity into the EU leaned to the side of a political separatism: EU27 and UK. Supporting Alesina et al. (2000), Gligorov (2004) claims that when trade is liberalized, nation sizes no longer matter. In addition, he identifies two situations that can lead to disintegration: (i) the group is not Pareto optimal,[31] and the regions will have interest in disintegration; and (ii) the group is Pareto optimal, and disintegration will benefit to certain regions (the richest) but not others (in this case there may be a conflict of interest).

31. Pareto efficiency or Pareto optimality is a situation where no individual or preference criterion can be better off without making at least one individual or preference criterion worse off.

Hiscox (2003) argues that globalization can generate greater support for both political integration and disintegration in different contexts. [32] These two trends may have been accelerated by globalization, that is, by growing economic integration in the international system.

5.2.3 Future of the EU and risk of EU collapse

Taking into account these elements, one of the big question deserves to be addressed: what is the future of the EU? Some authors risk analyses or opinions. Some of them predict the end of the EU. For Sampson (2017) it is too soon to know whether Britain leaving the EU will prove to be merely a diversion on the path to greater integration, a sign that globalization has reached its limits, or the start of a new wave of protectionism. Indeed, another possibility could be that the EU countries realize with Brexit the high costs of leaving the EU, which would support the first option of Sampson, namely a greater integration. On the contrary, for Mayer et al. (2019), we live in an age where it seems that the most likely outcome in the near future might be one of trade disintegration in Europe. Even before Brexit, according to Krastev (2012), the risk that the EU would disintegrate was more than a scare story that politicians are using to force austerity measures on unhappy voters. It already was a clear and present danger. The notion that the EU cannot fall apart because this would cost too much offers weak reassurance. The Habsburg, Soviet, and Yugoslav experiences suggest that the high economic costs of disintegration are not enough to keep it from happening.

An ancilliary question to address is: does the EU become too big? Consensus can hardly be reached (and even less unanimity) in a group of 27 or 28 members, and tensions can emerge. As an illustration, Hertz and Leuffen (2011) analyse how enlargements affect the speed of EU decision-making. In line with rationalist theories of group choice, they argue that enlargements increase the costs of organizing decisions, *i.e.* transaction costs. Increasing transaction costs, in turn, slow down EU law-making.

This slowness and possibly resulting inefficiency can be one of the ingredients for feeding populism and Euroskepticism. Concerning populism, Rodrik (2018) argues that the conventional assumptions that cosmopolitan and globalist values (and interests) would be ascendant, chipping away at national sovereignty, that global governance would be strengthened, all of these conventional have been upended by recent developments: the Brexit vote, but also Donald Trump's victory, and the rise of populist-nationalist parties in continental Europe. What all these share is an anti-establishment orientation, a claim to speak for the people against the elites, opposition to liberal economics and globalization,

32. *"On one hand, states have been delegating more responsibility over decision-making "upwards" to supranational institutions at global and regional levels."* – Example of the EU political integration and examples of the WTO and the IMF for recent trend towards regional integration and the strengthening of rule-making powers of international institutions.– *"On the other hand, recent years have also witnessed a great deal of political decentralization within states and a trend towards the devolution of decision-making powers "downwards" to sub-national political units."*(Hiscox, 2003)

and often (but not always) a penchant for authoritarian governance.

Following the trilemma theory, for Europe to remain democratic, and avoid authoritarian governance, either the people of Europe must develop a collective identity in place of their separate national identities (EU enhancement) or the supranational powers of the EU must be reduced (EU collapse). Otherwise, the tensions evident in the Brexit vote will recur in other countries and the EU may lose more members. Four years after the Brexit vote, the path is still very uncertain.

6 Discussion and conclusion

Brexit vote took place after a long path of disagreements with the EU. The trade-off between the loss of sovereignty and the economic benefits of the integration has been a regular issue since the begining of the UK membership. Many questions are raised concerning the agri-food trade between the UK and the EU, since they are big partners, and very integrated in the global value chains, and therefore interdependent. Outcomes of negiotiations are still uncertain, but a no-deal between the UK and the EU seems to be emerging. We identify the main risks for the EU agri-food trade and production, namely: (i) trade decrease in UK-EU trade; (ii) production costs increase and (iii) Irish border issue.

In the methods assessing Brexit impacts as change in trade policy, taking into account the NTMs is substancial, since they represent the majority of the trade barriers. Yet, no consensus has been found. This is directly linked to the fact that disintegration is generally conceptualized as the reverse of integration. Yet, the path to a state less integrated (A) to a state more integrated (B) is not the same than the path from B to A. It is very well demonstrated with the NTMs: it is very unlikely that NTMs difference between the UK and the EU after Brexit will go back to their level before the integration, because it would be too costly.

While integration has been widely studied, disintegration remains left behind, or simply considered as the reverse of integration. But if Brexit is just the first step of more disintegration, we can assume that interest in disintegration will be increasing and new assessment methods will appear. But is it? Are we entering in a new disintegration era, a new political sequence, where Brexit marks the beginning? While it is clear that Brexit represents a different kind of disintegration than the older ones, causes are still debated and no one can positively predict the EU future.

I highlighted and analysed the integration process and disintegration episodes, from an historical point of view, in order to understand the causes and the evolution and, based on these results, assume and debate hypotheses about the potential EU future. I found that the

tension between sovereignty and supra-national level of decision resulting from integration seems to be one of the key points.

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In the following chapters of the thesis we propose to assess some of the potential economic impacts of Brexit. We use gravity models to measure the bilateral trade flows variation in function of trade agreements scenarios, focusing on the EU and the agricultural and food trade.

Appendix A – HS nomenclature

Table A1: HS Chapters

Number	Name
01	Live animals
02	Meat and edible meat offal
03	Fish and crustaceans, molluscs and other aquatic invertebrates
04	Dairy produce; birds eggs; natural honey; edible products of animal origin, not elsewhere specified or included
05	Products of animal origin, not elsewhere specified or included
06	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage
07	Edible vegetables and certain roots and tubers
08	Edible fruit and nuts; peel of citrus fruit or melons
09	Coffee, tea, maté and spices
10	Cereals
11	Products of the milling industry; malt; starches; inulin; wheat gluten
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruits; industrial or medicinal plants; straw and fodder
13	Lac; gums, resins and other vegetable saps and extracts
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included
15	Animal or vegetable fats and oils and their cleavage products prepared edible fats; animal or vegetable waxes
16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates
17	Sugars and sugar confectionery
18	Cocoa and cocoa preparations
19	Preparations of cereals, flour, starch or milk; bakers' wares
20	Preparations of vegetables, fruit, nuts or other parts of plants
21	Miscellaneous edible preparations
22	Beverages, spirits and vinegar
23	Residues and waste from the food industries; prepared animal feed
24	Tobacco and manufactured tobacco substitutes

Appendix B – Integration and disintegration

B1. Integration and disintegration occurences

Table B1 presents the occurences on Econlit of words in titles over different periods.

Table B1: Occurences on Econlit of words in titles over different periods

Period	*"globalisation"* or *"globalization"*	*"integration"*	*"disintegration"*
Before 1980	0	128	15
1980 - 1990	45	3 691	26
1990 - 2000	1 651	20 121	118
2000 - 2010	5 651	38 908	118
2010 - 2020	2 855	43 908	132

Conclusion: The word *"integration"* is used much more than *"globalisation"* or *"globalization"*; *"disintegration"* is used very little, and it doesn't increase much over time.

B2. Detailed augmented trilemma problem

Robert Mundell and Marcus Fleming, from papers written separately by the two authors, designed the Mundell-Fleming model, through which they expand the traditional IS-LM model into a context of an open economy. This model explains why there cannot be an economy with an independent monetary policy if it maintains a fixed exchange rate, and there is free movement of capital and payments.[33] In other words, countries cannot simultaneously maintain independent monetary policies, fixed exchange rates, and an open capital account. It constitutes a familiar result of open-economy macroeconomics. This situation is known as the *"impossible trinity"*, or as the *"open economy trilemma"*. The trilemma is represented schematically in Figure B1. If a government chooses fixed exchange rates and capital mobility, it has to give up monetary autonomy. If it wants monetary autonomy and capital mobility, it has to go with floating exchange rates. If it wants to combine fixed exchange rates with monetary autonomy (at least in the short run), it had better restrict capital mobility.

Based on this model, Rodrik (2000) suggests, by analogy, a different kind of trilemma, one that we might call the political trilemma of the world economy, represented in Figure B2. The three nodes of the extended trilemma are integrated national economies, the nation-state, and mass politics. Rodrik uses the term *"nation-state"* to refer to territorial jurisdictional entities with independent powers of making and administering the law. He uses the term *"mass politics"* to refer to political systems where: (a) the franchise is unrestricted; (b) there is a high degree of political mobilization; and (c) political institutions are responsive to mobilized groups.

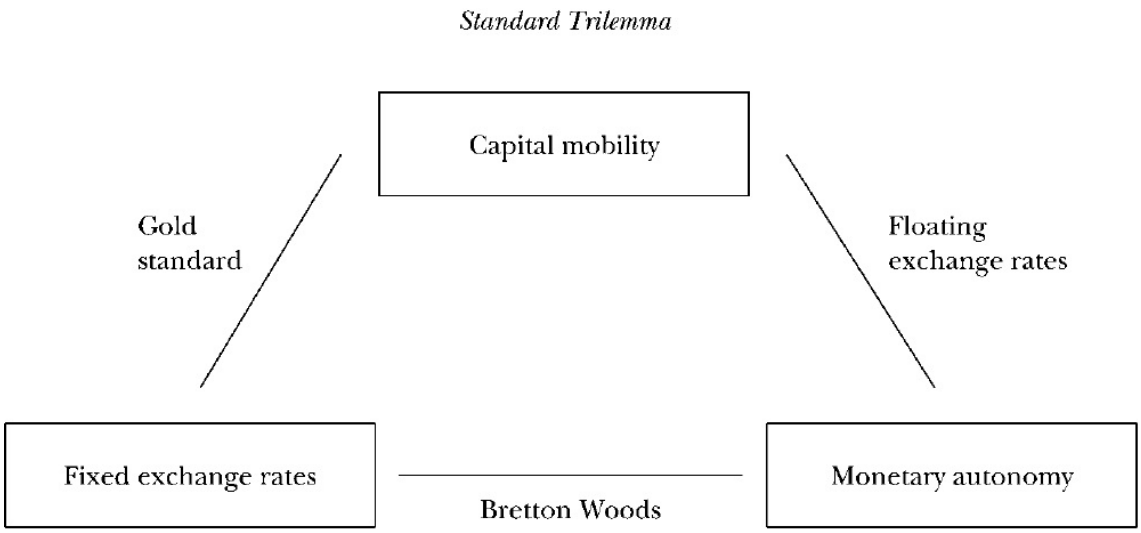
The implied claim, as in the standard trilemma, is that we can have at most two of these three things. If we want true international economic integration, we have to go either with the nation-state, in

33. https://policonomics.com/robert-mundell

which case the domain of national politics will have to be significantly restricted, otherwise with mass politics, in which case we will have to give up the nation-state in favor of global federalism. If we want highly participatory political regimes, we have to choose between the nation-state and international economic integration. If we want to keep the nation-state, we have to choose between mass politics and international economic integration.

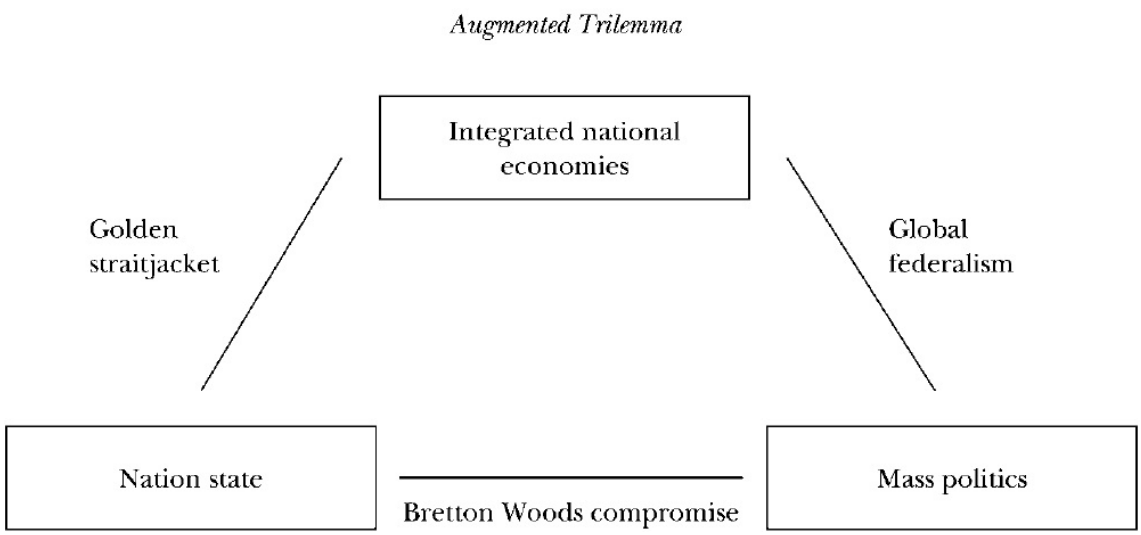
He claims we currently are unstable and he predicts we tend to a global federalism (grouping the two first elements), raising the question of the sovereignty (nation-state).

Figure B1: Standard trilemma problem



Source: Rodrik (2000)

Figure B2: Augmented trilemma problem



Source: Rodrik (2000)

Chapter II

How will Brexit affect the patterns of European agricultural and food exports? [1]

1. A version of this chapter co-authored with Angela Cheptea and Marilyne Huchet is being submitted to the ERAE journal (European Review of Agricultural Economics). It was presented at ETSG 2018 in Warsaw, Poland, and JRSS 2018 in Nantes, France.

1 Introduction

The United Kingdom (UK)'s decision to leave the European Union (EU) and its notification to the EU on 29 March 2017 (activation of Article 50 of the EU Treaty) mark a turning point in European history and raise many questions about the future economic relationships between the two parties. The agri-food sector has been caught in the middle of these events. The UK's large financial contribution to the EU's Common Agricultural Policy (CAP) was one of the main arguments of the pro-Brexit vote. Still, the fact that the UK is a net importer of agri-food products and an important destination market for EU agri-food exports suggests that a change in trade policy is likely to have important repercussions on this sector. The EU and UK agri-food sectors are strongly interconnected. The UK is highly dependent on agri-food imports from the EU, accounting for 69% of the country's total imports in this sector based on 2015 data (the year before the referendum). France is the UK's third largest foreign supplier of agri-food products, after Netherlands and Ireland. Reciprocally, the British market is the third destination of French agri-food exports, after Germany and Belgium, absorbing 9% of France's worldwide exports in this sector.

Most of the works in the literature evaluate the effects of Brexit at country level, and only a small number perform sector-level analyses. The present paper investigates the effects on the EU agri-food sector. We aim to identify the products and EU countries most harshly to be affected by Brexit. For that, we estimate the change in UK-EU trade flows on the entire agri-food sector and thirteen groups of products, both at country-level and by bilateral trade relationships, under different scenarios.

The uncertainty on the outcome of the EU-UK negotiations and the grim prospects of reaching a deal in the near future opens the door to a large array of possible post-Brexit trade policy scenarios. We consider five post-Brexit trade policy scenarios. Differently from previous studies, our scenarios include assumptions not only on the outcome of EU-UK trade negotiations, but also on the future trade relationships between the UK and its non-EU partners. First, we consider two possible solutions for the future UK-EU trade relationship: a free trade agreement (FTA) similar to, but deeper than, CETA (EU-Canada Comprehensive Economic and Trade Agreement), and a return to World Trade Organization (WTO) rules. Then, for each of these two cases, we consider two options for ruling trade between the UK and non-EU countries: the replication of EU trade agreements and preferential trade agreements (PTAs) with the UK's largest non-EU partners. Combining the two policy alternatives for the EU-UK trade relationship and two options for the UK's trade relationship with third countries, we obtain four symmetric trade policy scenarios. We add a fifth scenario to reflect the UK's intention to liberalize its market in case of a no-deal exit from the EU, disclosed in March 2019. All scenarios are defined by changes in import tariffs and non-tariff measures (NTMs).

We use a structural gravity model and estimate the effects of Brexit following the approach developed by Anderson et al. (2018). This choice is motivated by a number of factors. Being designed to estimate effects at the bilateral level, the model permits to quantify (more accurately than other approaches) trade diversion between the UK and each EU country. Structural gravity is better adapted for estimating effects at product (or product group) level. It also allows to include a very detailed bilateral trade cost function and to control for both bilateral and unilateral trade determinants without making strong and hard to check assumptions. We estimate the direct effects of Brexit corresponding to changes in trade costs (partial equilibrium effects), as well as the indirect effects induced by changes in multilateral resistance, output, and expenditure (general equilibrium effects). We base our computations on data over the period 2012-2015, as the baseline for the predictions. Our data panel starts in 2012, after the effects of the 2008-2009 economic crisis were completely absorbed in most countries, and ends in 2015, the year before the Brexit referendum.

A lot of uncertainty hangs over the outcome of the UK's trade negotiations. Future trade agreements will affect the costs of trading with UK (higher for EU countries, possibly lower for some non-EU countries), and will strengthen the competition on the UK market, as well as on all markets to which trade will be diverted. Our results reflect long-term impacts. They should permit to guide EU decision-makers in the ongoing negotiations, and to anticipate the negative effects for the agri-food sector.

The remainder of the paper is structured as follows. The next section summarizes the ongoing UK-EU negotiation process. Section 3 describes the methodology and data. Results of the five scenarios are presented and discussed in Section 4. Section 5 presents the effects by group of products and Section 6 resumes our main conclusions.

2 Context of negotiations and scenarios: a brief review of the literature

2.1 Ongoing negotiations

Brexit negotiations were led by Michel Barnier for the EU, and by British Prime Ministers Theresa May and Boris Johnson for the UK. The very different positions adopted by the UK and the EU, and the need to obtain the agreement of each of the 27 EU countries increased the difficulty of negotiations. The tight margin of the Brexit vote and strong differences in results (position pro or against Brexit) across British regions, socio-economic groups, and age groups prevented the country's main political parties to adopt a uniform position on Brexit. Both the governing (Tory/Conservative) and the opposition (Labor) parties counted a large number of Brexit supporters and Brexit opponents, which complicated even more the negotiations. Surprised by the outcome of the Brexit vote, the then Prime Minister David

Cameron resigned shortly after the vote. Brexit negotiations were launched under Theresa May, who stepped in office in July 2016. On 29 March 2017 the UK notified its intention to withdraw from the EU and a two-phase negotiation process began. In December 2017, both parties declared that sufficient progress had been made in the negotiations on the first phase dealing with citizens' rights, the UK's *''divorce bill''*[1] and the Irish border for paving the way for discussions on the future trade relationship (European Commission, 2017). Still, the need for a transition arrangement has been accepted by both parties.

On 28 February 2018, the European Commission published a first draft Withdrawal Agreement on the progress achieved during phase one of the negotiations.[2] From the beginning of the negotiations, the UK has spelled out its intention to negotiate a bold and ambitious free trade agreement with the EU, while respecting four red lines: (1) ending the jurisdiction of the European Court of Justice, (2) controlling immigration from the EU, (3) ending most contributions to the EU budget, and (4) being able to strike trade deals with third countries. The EU adopted a firm position that a non-member of the Union cannot enjoy the same rights and benefits as a member country and condemned the UK's cherry-picking attitude.

On November 25 2018, after several rounds of negotiations, the EU27 and the UK government reached a Withdrawal Agreement.[3] Although the document was endorsed by leaders of EU countries and the British government, it was rejected by the UK Parliament on three repeated votes (January 15, March 12 and 29, 2019). A central point of the agreement was the Irish backstop, a protocol describing the provisions that would prevent introducing a hard border between the Republic of Ireland and Northern Ireland after the UK leaves the EU. According to it, if no EU-UK trade deal is reached by the end of the transition period (31 December 2020), Northern Ireland would remain in the EU's Single Market, unlike the rest of the UK, and the UK would shadow the EU's common external tariff. Roughly, this would move the land border between the UK and the EU from the island of Ireland to the Irish Sea (*i.e.*, within the UK) until an alternative arrangement is reached between the EU and the UK.

A revised Withdrawal Agreement was negotiated in October 2019 with the Johnson's government. The Irish backstop was replaced by a new protocol, according to which the whole of the UK exits the EU Customs Union as a single customs territory, but Northern Ireland adopts EU Single Market regulations on goods in order to prevent a hard border and remains an entry point into the EU Customs Union. It sets the *de jure* customs border on the

1. The financial settlement that the UK is to pay to the EU.
2. https://ec.europa.eu/commission/sites/beta-political/files/draft_withdrawal_agreement.pdf
3. The Withdrawal Agreement included a backstop to ensure that there would be no physical frontier between the two Irelands, a transition period to negotiate the future relationship between the EU and the UK, protocols with Spain and Cyprus on parties' commitments over Gibraltar and, respectively, Sovereign Base Areas. The agreement was accompanied by a Political Declaration, setting out the scope and terms of the future EU-UK relationship.

island of Ireland, but the *de facto* customs border on the Irish Sea. Also, the UK collects import tariffs on behalf of the EU on goods shipped from Great Britain[4] to Northern Ireland that are *"at risk"* of being transported into and sold in the Republic of Ireland. The protocol also includes a unilateral exit mechanism for Northern Ireland, which votes every four years on whether to continue these arrangements or not. The revised Brexit Withdrawal Agreement was ratified by the UK and the EU, and came into force on 1 February 2020. This marks the end of the first phase of Brexit negotiations and the beginning of negotiations of a future EU-UK trade agreement. According to the Withdrawal Agreement, the transition period ends on 31 December 2020, but can be extended once by mutual consent.

2.2 Quantifying Brexit trade effects, a brief literature review

The economic literature abounds with studies on economic integration, a large number of them focusing on integration within Europe. Episodes of disintegration were analysed by economists mostly from a historical perspective (*e.g.* Head et al., 2010, on the deterioration of post-colonial trade; de Menil and Maurel, 1994, on the breakup of the Austro-Hungarian empire), or from a change of the economic system (*e.g.* Maurel and Cheikbossian, 1998, Djankov and Freund, 2002, Fidrmuc and Fidrmuc, 2003, on the collapse of the Soviet Union, the dissolution of Yugoslavia and of Czechoslovakia). In this context, Brexit comes as an unprecedented example of economic disintegration and marks a downturn in the recent history of increased integration and globalization that has characterized the past seven decades.

Buch and Toubal (2009) and Nitsch and Wolf (2013) show, on the case of German re-unification, that borders have a long-lasting effect on trade flows and trade openness. They find a persistent impact of the former East-West border on German domestic and foreign trade flows even fifteen years after the fall of the Berlin Wall. Nitsch and Wolf (2013) estimate that it will take 33 to 40 years to remove the impact of this political border on German trade. These results raise the question of how quickly Brexit will dissolve the EU-UK ties and partnerships developed over the 47 years of joined economic integration, and how rapidly the economic and commercial impediments introduced by Brexit will be reflected in European and British trade patterns.

Over the last years, a number of studies evaluating the economic costs and benefits of Brexit with different methodological approaches have emerged in the literature. Some authors focus more generally on economic disintegration and consider Brexit as a specific illustration of this process (*e.g.*, Sampson, 2017; Larue, 2018). A large number of works

4. We remind that Great Britain (GB) is a geographic term referring to the island also known simply as Britain. It's also a political term for the part of the UK made up of England, Scotland, and Wales. United Kingdom (UK) represents the independent country that encompasses all of GB and the region now called Northern Ireland.

evaluate the effects of Brexit using a computable general equilibrium model (*e.g.*, HM Treasury, 2016b; Kierzenkowski et al., 2016; OECD, 2016; Bellora et al., 2017; Copenhagen Economics, 2018; Erken et al., 2018; Jafari and Britz, 2020; Figus et al., 2018). Some analyses assimilate Brexit to the opposite of the EU membership effect and use counterfactual analysis to evaluate its impacts on economic growth, gross domestic product (GDP), foreign investment, and trade (Campos et al., 2014; Crafts, 2016; Bruno et al., 2017; Mayer et al., 2018). Born et al. (2019) and Douch et al. (2018) use matching algorithms to construct the counterfactual value of UK's GDP, consumption, investment, and foreign trade that would have been observed in the absence of the Brexit vote. Other studies, including van Berkum et al. (2018), Davis et al. (2017), and van Berkum et al. (2016), use partial equilibrium models adapted to the agricultural sector. Finally, Dhingra et al. (2017), Oberhofer and Pfaffermayr (2017), and Bradley and Hill (2019) use a structural gravity approach to estimate the effects of Brexit on trade and welfare. More differently, Graziano et al. (2020) and Douch et al. (2020) focus on the effects of trade policy uncertainty introduced by Brexit. All these studies find a strong negative impact on the British economy and a smaller negative effect on the EU, unevenly distributed across member countries, although the magnitude of effects differs significantly.

Besides this methodological variety, there are also distinctions according to the geographic areas analysed. While some studies focus on the impact of Brexit on the British economy, others place the UK's trade partners in core of the analysis. For instance, Lawless and Morgenroth (2019) use a general equilibrium model and analyse the effects on EU countries (on both British exports to EU countries and EU exports to the UK) by taking into account the great variation in tariffs across products, which fills in a gap in aggregate studies. Their results show an extremely wide range of country-level reductions in trade with the UK. For a number of EU countries – Estonia, Finland, Latvia and Slovenia – the estimated impact on total trade is minimal, less than half of one per cent. Ireland is the most severely affected with an estimated 4% drop in exports. The food sector is one of the hardest hit sectors, with bilateral EU-UK expected to drop by up to 90% in case of a no deal scenario (especially for meat and confectionary products). Copenhagen Economics (2018) emphasizes the effects on the Irish economy. Whatever the scenario analysed, they find that Brexit will have negative impacts on Irish trade, with adverse knock-on effects on Irish production and ultimately Irish GDP. By 2030, the latter is estimated to be 2.8% to 7% lower than the non-Brexit baseline GDP level. Besides, agri-food is one of the five most affected sectors, the predicted fall in trade and production being the largest for processed foods, beef, sheep and other cattle meat, and dairy.

Most analyses are carried on all economic sectors combined. Davis et al. (2017), van Berkum et al. (2018), Bradley and Hill (2019) are some of the few that focus on the effects of Brexit on the agricultural and food sector with the UK. For instance, van Berkum et al. (2018) concentrate on impacts in Dutch trade and especially focus on changes in both total

agricultural exports and exports of individual agricultural products. They find that Dutch exports to the UK and the rest of the world will be affected only marginally, either under a free trade agreement between the EU and the UK or a WTO scenario. Davis et al. (2017) show that the impacts on prices and the value of production in the UK agricultural sector vary greatly by products.

Finally, most studies analyse the effects at country level. Still, a handful of studies illustrate the variation of effects across EU and British sub-national regions (Chen et al., 2018; Figus et al., 2018). Chen et al. (2018) construct an index reflecting the degree to which regions and countries are exposed to negative trade-related consequences of Brexit, accounting for the geographical fragmentation of the production process. They find that British regions are far more exposed than comparable-size regions in EU countries. The most affected EU region is the Republic of Ireland, with exposure levels similar to UK regions, followed by German, Dutch, Belgian and French regions.

2.3 What about the possible scenarios?

If the UK leaves the EU without a trade agreement, producers and consumers on both sides will have to absorb the additional trade costs induced by the introduction of import tariffs, customs clearance procedures, regulatory, sanitary and phytosanitary checks and food safety controls of traded products, as well as tighter regulation of road transportation.

The burden of these changes will be particularly strong on agri-food products, which include many perishable goods, are subject to a large number of border controls, and often require specialized control and transportation equipment (see Matthews, 2017a, for a detailed discussion). Although both the UK and the EU declare their willingness to prevent or limit the increase in bilateral trade costs, Brexit will unavoidably increase the costs of shipping goods across the English Channel under any scenario on the future EU-UK trade relationship.

A number of probable scenarios emerge from the negotiation process, but uncertainty still looms on both sides, especially about how much integration should remain between the UK and the EU. The shape of the future trade relationship will not be known until negotiations are successfully concluded or no agreement is reached by the end of the transition period. The present paper questions the effects of long-term trade policy arrangements. Even if a Withdrawal Agreement was already reached and the transition period approached its end, the future trade relationship is not settled yet. Therefore, we consider an array of possible outcomes – on the bilateral EU-UK trade policy and the UK's trade policy with respect to third countries – that we express into five distinct scenarios.

A number of potential trade policy scenarios for the future long-term relationship between the UK and the EU27 have been studied in the literature. Matthews (2017a) discusses in detail the EU's agreements with Canada, Turkey, Ukraine, Swiss and Norway as possible models for a future EU-UK trade agreement, and confronts them to the four red lines set out by the UK during Brexit negotiations, listed in section 2.1. He concludes that, while respecting its four red lines, the UK has set out its ambition for a bold and ambitious free trade agreement with the EU, making a free trade agreement highly probable, in the form of a *''CETA+''* type, *i.e.* a deep and comprehensive economic and free trade agreement similar to the one concluded by the EU and Canada.

This type of trade arrangement would keep zero tariffs, would not require full freedom of movement of citizens, nor budgetary transfers, and would introduce minimal requirements for regulatory alignment between the EU and the UK, but also some non-tariff measures (NTMs), at least for checking the compliance with the partner's regulations in cases where alignment does not apply. This type of agreement does fully reflect the broader negotiation position (preferences and conditions, beyond the red lines) defended by the UK and the EU. The EU rejects any deal that dissociates the four pillars of the single market (the free movement of goods, services, capital and people), while the UK wants to avoid NTMs and, at the same time, limit regulatory alignment with the EU. In addition to the relationship with the EU, the UK trade relationships with third countries (*i.e.* outside the EU) will also be subject to change. Thus, another aspect of the scenarios concerns the future UK-third countries trade agreements.

The most common approach in the literature on the effects of Brexit is to consider two extreme scenarios, a *''hard''* and a *''soft''* Brexit. The *''hard Brexit''* scenario assumes that the UK will leave the EU and end its current (free or preferential) trade agreements with both the EU and third countries. Furthermore, this scenario assumes that no new free trade agreement between the EU and UK could be established. As a consequence, the UK would trade with all countries, including EU members, based on WTO regulations. The *''soft Brexit''* scenario assumes that the UK will conclude a FTA with the EU and will pursue all trade agreements with third countries inherited from the EU. Most of the papers mentioned in section 2.1 analyse these extreme scenarios. Some intermediary scenarios concerning the EU-UK agreement are also considered the literature. For example, Dhingra et al. (2017) set up a general equilibrium trade model that covers 31 sectors and aggregates the world into 35 regions, and assume three post-Brexit trade policy options: the UK remains part of the EU Single Market like Norway, the UK negotiates bilateral agreements with the EU as have done Switzerland and Canada, or the UK and the EU fail to reach a deal and trade between the two takes place on WTO terms.

Using a partial equilibrium modelling framework, Davis et al. (2017) find that the estimated changes are relatively small under an EU-UK free trade agreement scenario and larger under

the WTO scenario. Besides, the projected impacts vary across sectors or groups of agricultural commodities, and on whether the UK is a net importer/exporter of these products. Davis et al. (2017) find that Brexit will generate a rather strong price increase in the dairy, beef, pig and poultry sectors, but not for cereals. Finally, they find a decline in prices and the value of production under the UK's unilateral trade liberalization scenario, which are particularly marked for beef and sheep sectors.

In the same vein, van Berkum et al. (2016) use a sectoral model to quantify the possible effects of Brexit on agricultural trade and farmers' income levels. They also consider three scenarios: a UK-EU free trade arrangement, a WTO position, and a UK trade liberalization scenario, which they combine with three different levels of agricultural support in the UK. Under the first two scenarios, UK farm gate prices increase due to higher transaction costs, generating an improvement of the UK's trade balance (mainly lower imports), but also a loss of consumer welfare. By contrast, the scenario implying a unilateral trade liberalization of the British market leads to more openness to trade. The latter shows the most significant changes with farm incomes declining in all regions except for England-East. Under this scenario, farm incomes are the most severely affected in Scotland.

Bradley and Hill (2019) construct a micro-economic farm-level model from the average Farm Business Survey using a gravity model for estimating changes in commodity prices resulting from trade conditions. They examine impacts on farmers' incomes in England, Scotland and Wales. They estimate that under a FTA scenario the average farm income would fall by 2022 for all farms, except the sheep and beef sectors. They also find strong negative impacts under the WTO scenario in all sectors.

In the present study, we consider two scenarios for the future UK-EU trade arrangements: (i) a free trade agreement similar to, but deeper than, CETA, usually referred in the literature as the *"optimistic scenario"* and close to the *status quo*, and (ii) a return to WTO rules, usually referred in the literature as the *"pessimistic scenario"*. For each of these scenarios, we set two possible outcomes for the UK's arrangements with non-EU trade partners. We consider (a) a replication of current EU agreements with third countries, or (b) preferential trade agreements with UK's main extra-EU partners (more ambitious than EU agreements) and a return to WTO rules for the rest of countries. We also consider a fifth scenario of unilateral liberalization of the British market, consisting in the removal of tariffs on the UK's imports of all agri-food products from all source countries (Table 1).

To smooth the impacts of the shock on the British economy, on 13 March 2019, the UK government announced that, in case of a no-deal exit, it would remove tariffs on 87% of the UK's imports and apply a temporary tariff significantly lower than the EU's MFN tariff on the remaining 13%. Even if these temporary tariffs concerned only 13% of the products imported by the UK, most of them referred to a small number of agri-food goods. If this

tariff scheme were applied, non-EU suppliers would benefit from improved access to the British market, the effect being strongest for countries currently facing the highest EU import tariff, such as the United States of America (USA) and China (Cheptea and Huchet, 2019). These tariffs would apply equally to all trade partners, except countries with which the UK has negotiated a free trade agreement and the around 70 developing countries that enjoy a preferential access to the British market.[5]

On May 19, 2020, the British Government has announced the UK's new MFN tariff regime, the UK Global Tariff (UKGT), that will replace the EU's Common External Tariff at the end of the transition period (currently set for January 1, 2021) if no trade agreement is reached with the EU. According to UK government, the UKGT is a simpler, easier to use and lower tariff regime than the EU's Common External Tariff (EU CET), with specific duties expressed in British pounds (£) rather than euros. It was designed to scrap red tape and other unnecessary barriers to trade, reduce cost pressures, increase choice for consumers, and back UK industries to compete on the global stage. The UKGT also expands tariff free trade by eliminating tariffs on a wide range of products. The UK Global Tariff almost doubles the number of tariff free products relative to what is currently applied: 47% of products have nil tariffs in the UKGT compared to only 27% in the CET. Shall the product composition of British imports remain unchanged, under the UKGT 60% of trade will enter the UK tariff free on WTO terms or through preferential access, and this share will increase with the successful negotiation of future FTAs. Import tariffs will be maintained on a number of products backing UK industries such as agriculture, automotive and fishing (*e.g.* lamb, beef, poultry). The UK Global Tariff liberalizes tariffs on a small number of cereal products (maize, sorghum and rye) and removes the variable rate of duties applied by the EU's Common External Tariff where the tariff is increased when global prices fall.

The UK's recent attempt to pass a bill that annuls some of the provisions of the Withdrawal Agreement, and the consolidation of British and European governments' resources on limiting the effects of the Covid-19 pandemic mount the EU-UK tensions and decrease the odds of a trade deal being concluded by the end of 2020. Our scenario *"liberalized UK"* approaches the most this increasingly likely outcome.

In the above scenarios, a free trade agreement between the UK and EU countries implies nil import tariffs on bilateral trade, and an increase in the difference of pre-shipment non-tariff measures to the level observed for the UK's trade with partners with which it has no preferential trade arrangement. Since the UK already complies with the EU standards and norms in a large number of sectors, a hard Brexit would most probably not imply a change in the UK's sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT),

5. Chile, ESA Countries, Faroe Islands, GSP scheme (excl. India, Indonesia, and Kenya), GSP+ Countries, GSP scheme (India), GSP scheme (Indonesia), Israel, Least Developed Countries (LDC), Palestinian Authority, Switzerland.

the main type of NTMs that affect agri-food trade. A preferential trade agreement (PTA) between the UK and its main non-EU trade partners is modelled as a 50% decrease in import tariffs and in the difference between British and European pre-shipment measures.

Table 1: The description of trade policy scenarios

		Trade arrangements between the UK and the EU	
		(i) Deep UK-EU FTA	(ii) WTO rules
Trade arrange-ments between the UK and its partners outside the EU	(a) Replication of EU agreements with third countries; WTO rules with non-EU partners	***UK-EU FTA & replication of EU's FTAs*** ***(S1)***	***Fortress UK*** ***(S2)***
	(b) PTA with main non-EU partners; WTO rules with the rest	***UK-EU FTA & PTA with main non-EU*** ***(S3)***	***PTA with main non-EU & WTO rules with the rest*** ***(S4)***
		Total liberalization of the British market ***Liberalized UK (S5)***	

We consider the USA, Australia, New Zealand, Switzerland, Chile, and Israel the UK's main extra-EU trade partners with which it will most likely negotiate PTA . This list includes the top three developed countries trading with the UK that currently do not have any trade arrangement with the UK (the USA, Australia and New Zealand) and the three countries with which the UK has already negotiated a PTA (Switzerland, Chile, and Israel). We excluded the emerging countries that count among the UK's main trade partners, such as China and India. Despite their large volume of trade with the UK, these countries have a high level of protection of their domestic agricultural markets. Therefore, we find it very unlikely that the UK would easily reach a trade agreement with any of them. The scenario of unilateral liberalization of the British market is modelled by setting the UK's tariffs on imports of all products from all trade partners equal to zero. The difference in pre-shipment non-tariff measures between the UK and EU countries is set equal to the average difference observed between the UK and countries with which it has no preferential trade arrangement.

Our five scenarios offer some lower and upper bounds for the possible change in the UK's trade costs, and hence for the effects of Brexit. Comparing the results of different scenarios, we apprehend how exposed are British and EU agri-food exports to the change in the UK's trade deals with the EU and with third countries.

3 Methodology and data

3.1 Structural gravity

We aim to estimate the effects of Brexit in terms of changes in UK-EU trade flows. We focus not only on the direct changes in the trade flows of changes in trade costs after Brexit, but also on the indirect impact of these changes on other trade flows via adjustments in price indices, expenditure and output levels.

We build a structural gravity-model following Anderson et al. (2018). We assume a demand model with a representative consumer with homothetic preferences maximizing a constant elasticity of substitution (CES) utility function under a budget constraint, and assume market clearance for goods from each origin (*i.e.* balanced trade). The consumer's optimization problem yields the following expenditure on goods shipped from origin i to destination j:

$$X_{ijt} = Y_{it} E_{jt} \left(\frac{\tau_{ijt}}{\Pi_i P_j} \right)^{1-\sigma} \varepsilon_{ijt} \tag{1}$$

X_{ijt} denotes the value of exports from origin country i to destination country j in year t at destination prices (as paid by consumers in j), E_{jt} is the expenditure of consumers in destination country j on products from all origins, Y_{it} is the value of output of goods produced in origin country i, τ_{ijt} are the bilateral trade costs between the two countries, Π_i and P_j reflect the ease of access to the global market of exporter i and respectively importer j, $\sigma > 1$ is the elasticity of substitution of goods from various origins, and ε_{ijt} is a zero-mean error term.

The term $\left(\tau_{ijt}/\Pi_i P_j\right)^{1-\sigma}$ captures the total effects of trade costs that drive a wedge between observed and frictionless trade. It consists of three components: the bilateral trade cost between partners, τ_{ijt}, approximated in the literature mainly by geographic and trade policy variables (*i.e.* distance and import tariffs), and two structural terms, Π_i and P_j, coined by Anderson and van Wincoop (2003) as the outward multilateral resistances (OMR) and the inward multilateral resistance (IMR). The model's assumptions (utility function, market clearance, multiplicative trade costs) establish the links between the two multilateral resistance (MR) terms and other variables of the model:

$$\Pi_{it}^{1-\sigma} = \sum_j \left(\frac{\tau_{ijt}}{P_{jt}}\right)^{1-\sigma} E_{jt} \tag{2}$$

$$P_{jt}^{1-\sigma} = \sum_i \left(\frac{\tau_{ijt}}{\Pi_{it}}\right)^{1-\sigma} Y_{it} \tag{3}$$

Equation (1) is referred in the literature as the gravity model of international trade. Adding the constraints expressed by equations (2) and (3), one obtains a structural gravity model.

According to Brakman et al. (2017), MR terms are at the core of modern formulations of gravity models. They are often interpreted as price indices and are crucial to analyse the effects of a change in trade policy. Without these terms, the simulated effects of a trade policy change would only affect the two countries involved. Including these terms, one account as well for effects on countries' access to the global market, *i.e.* the way the change in trade policy affects the entire trading system.

3.2 Estimation strategy

We start by estimating equation (1) for each product group using the Pseudo-Poisson Maximum Likelihood (PPML) estimator introduced by Santos Silva and Tenreyro (2006). In addition to controlling for heteroscedasticity in the data, the PPML also permits to include nil trade flows, which represent a large fraction of the data disaggregated by sector or product groups. Estimating the unbiased trade effects of bilateral determinants requires to account for the time-varying supply, demand, and alternative destinations and sources of supply (*e.g.* Baldwin and Taglioni, 2006; Didier and Koenig, 2019). Following the common practice in the literature on theory-consistent estimation of the gravity model, we control for these variables using time-varying country (importer and exporter) fixed effects ψ_{it} and χ_{jt}. We use an expression of trade costs that combines the main determinants employed in the empirical trade literature and the main elements of a country's trade policy:

$$\tau_{ijt} = {d_{ij}}^{\beta_1/(1-\sigma)} \exp\left(CNTG_{ij}\right)^{\beta_2/(1-\sigma)} \exp\left(LANG_{ij}\right)^{\beta_3/(1-\sigma)} \exp\left(CLNY_{ij}\right)^{\beta_4/(1-\sigma)} \times \\ \times \left(1 + tar_{ijt}\right) \prod_m \exp\left(NTM_{ijt}^m\right)^{\delta_m/(1-\sigma)} \tag{4}$$

where d_{ij} is the bilateral distance between the two countries, $CNTG_{ij}$, $LANG_{ij}$, $CLNY_{ij}$ are dummy variables equal to one when countries share a common land border, language, or colonial past, tar_{ijt} is the applied import tariff expressed in *ad-valorem* equivalent, and NTM_{ijt}^m are a range of variables measuring the dissimilarity of the two countries' non-tariff

measures for each type m of NTM (regulatory distances). To our knowledge, regulatory distance has been used in previous works only as an output variable, but not as an element of trade costs. In the literature, the impact of NTMs on trade flows is usually apprehended by the number of measures (per importing country and product), the ratio of trade covered by NTMs, and the fraction or the number of tariff lines subject to NTMs. The correct estimation of the structural gravity model requires the use of directional country-year fixed effects. This does not permit to identify separately the impact of country-specific components of trade costs, such as the number of NTMs for a given product or group of products in the exporting and the importing country. The effect of these and other country-specific variables is captured in country fixed effects ψ_{it} and χ_{jt}. To overcome this limit, we use the regulatory NTM distance as a novel strategy to proxy the discrepancies in NTMs across countries.

The import tariff enters the trade cost equation (4) with unit elasticity. Therefore, introducing expression (4) into equation (1) with yearly importer and exporter fixed effects yields a trade equation permitting to directly estimate the elasticity of substitution σ:

$$X_{ijt} = \exp\big[\beta_1 \ln d_{ij} + \beta_2\, CNTG_{ij} + \beta_3\, LANG_{ij} + \beta_4\, CLNY_{ij} + \\ +(1-\sigma)\ln\big(1 + tar_{ijt}\big) + \textstyle\sum_m \delta^m NTM_{ijt}^m\big] \times \psi_{it}\, \chi_{jt}\, \varepsilon_{ijt} \qquad (5)$$

Estimated fixed effects capture the terms specific to each exporter and importer:

$\hat{\psi}_{it} = Y_{it}/\Pi_i^{1-\sigma}$; $\hat{\chi}_{jt} = E_{jt}/P_j^{1-\sigma}$. The structure of the model, reflected by equations (2) and (3), permits to separate the effect of MR terms from that of expenditure and output, as the latter can be computed from observed trade data:

$$E_{jt} = \textstyle\sum_i X_{ijt}\ ; \quad Y_{it} = \sum_j X_{ijt} \qquad (6)$$

Solving the general equilibrium trade model requires information on trade flows between all country pairs, including a country's trade with itself. We use the estimates of country fixed effects $\hat{\psi}_{it}$ and $\hat{\chi}_{jt}$ together with parameter estimates from equation (5) to compute unobserved domestic trade flows:

$$X_{iit} = \exp\big(\hat{\beta}_1 \ln d_{ii}\big)\, \hat{\psi}_{it}\, \hat{\chi}_{it} \qquad (7)$$

We can now turn to computing the effects of a change in trade costs. Each trade policy scenario analysed in the paper corresponds to a hypothetical level of trade costs after Brexit, obtained by changing the values of trade policy variables for trade flows involving the UK. For each scenario, we identify the corresponding matrix of trade flows (as well as the MR,

expenditure and output levels) that satisfy the set of equations (2) – (3) and (5) – (7). To find this new equilibrium, we follow the procedure developed by Anderson et al. (2018). The gap between the exports already estimated in the first step and these new simulated exports reflects the trade impact of Brexit on agricultural and food exports according to the considered scenario.

First, we keep the baseline values of Π_{it} and P_{jt} unchanged, which implies fixing the level of countries' output and expenditure, and predict the level of trade flows and other variables of the model corresponding to the partial equilibrium that accounts only for the direct effect of the change in trade costs. Second, we re-compute MR terms Π_{it} and P_{jt} and countries' output and expenditure levels by integrating the change in trade costs, plug the new values into the model and repeat this procedure until convergence. This yields the level of trade flows and other variables under general equilibrium, and the indirect effects of the change in trade costs.

We estimate the model on observed 2012-2015 bilateral trade flows using the Pseudo Poisson Maximum Likelihood (PPML) approach developed by Santos Silva and Tenreyro (2006, 2011), which permits to account for nil flows and correct for heteroscedasticity in the data. We rely on a very convenient feature of the PPML estimator demonstrated by Fally (2015) that estimated fixed effects are exactly equal to the multilateral resistances that satisfy the structural gravity model.

Table 2 resumes our five Brexit scenarios based on the trade costs specification expressed by equation (4). For each scenario, we use estimated parameters to compute the level of trade costs and of corresponding trade flows. We re-estimate the model on these new values of trade costs and trade flows by keeping marginal effects of all trade cost variables (parameters β_1 to β_4 and δ_m) equal to their initially estimated values on observed data, and use the model's structure to compute countries' adjustments to the new trade environment in terms of price indices (multilateral resistances), output and expenditure levels. Finally, we plug all these results into the model and compute the ultimate level of counterfactual trade flows under each scenario. The evolution of trade flows under each scenario with respect to observed flows offers an apprehension of the magnitude of the effects of Brexit on international trade in agri-food products.

Table 2: Five Brexit scenarios

	EU-UK trade	UK's trade with its top six non-EU partners	UK's trade with the rest of non-EU
Scenario S1 ***'FTA with EU & replication of EU's FTAs'***	$tar_{ijt} = 0$ (unchanged) NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} as under the MFN regime NTM_{ijt}^{E} unchanged	tar_{ijt} unchanged NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} unchanged NTM_{ijt}^{E} unchanged	
Scenario S2 ***'Fortress UK'***	$tar_{ijt} = MFN\ tar_{ijt}$ NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} as under the MFN regime NTM_{ijt}^{E} unchanged	tar_{ijt} unchanged NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} unchanged NTM_{ijt}^{E} unchanged	tar_{ijt} unchanged NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} unchanged NTM_{ijt}^{E} unchanged
Scenario S3 ***'FTA with EU & PTA with top non-EU'***	$tar_{ijt} = 0$ (unchanged) NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} as under the MFN regime NTM_{ijt}^{E} unchanged	$tar_{ijt} = 0.5 * tar_{ijt}$ NTM_{ijt}^{A+B} unchanged $NTM_{ijt}^{C} = 0.5 * NTM_{ijt}^{C}$ NTM_{ijt}^{E} unchanged	$tar_{ijt} = MFN\ tar_{ijt}$ NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} as under the MFN regime NTM_{ijt}^{E} unchanged
Scenario S4 ***'PTA with top non-EU & WTO rules with the rest'***	$tar_{ijt} = MFN\ tar_{ijt} = 0$ NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} as under the MFN regime NTM_{ijt}^{E} unchanged	$tar_{ijt} = 0.5 * tar_{ijt}$ NTM_{ijt}^{A+B} unchanged $NTM_{ijt}^{C} = 0.5 * NTM_{ijt}^{C}$ NTM_{ijt}^{E} unchanged	$tar_{ijt} = MFN\ tar_{ijt}$ NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} as under the MFN regime NTM_{ijt}^{E} unchanged
Scenario S5 ***'Liberalized UK'***	$tar_{ijt} = 0$ (unchanged) NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} as under the MFN regime NTM_{ijt}^{E} unchanged	$tar_{ijt} = 0$ NTM_{ijt}^{A+B} unchanged NTM_{ijt}^{C} unchanged NTM_{ijt}^{E} unchanged	

3.3 Data

We use a trade costs structure combining tariffs, non-tariff measures, geographic distance, and standard variables on bilateral linkages between trading countries used in the trade literature (common land border, common language, and common colonial past). Accordingly, our final data panel is obtained by combining several sources of data.

Trade flows at the HS 6-digit level come from the BACI database. Geographical distances and bilateral links between countries (common land border, common language, and common colonial past) are obtained from the CEPII. Data on import tariffs and non-tariff measures at the HS 6 level come from the UNCTAD's[6] TRAINS[7] database. We use the applied import tariffs computed by UNCTAD from data on reported *ad-valorem* duties and specific duties converted in *ad-valorem* equivalents. Most non-tariff measures vary only across importing countries and products. One cannot separate the effect of this variable from other importer-specific terms in the model. To overcome this limit, we compute NTM regulatory distances following the approach introduced by Cadot et al. (2015) using original UNCTAD data on the number of NTMs applied at the HS 6-digit product level to. For each NTM type *m*, the regulatory distance is the normalized distance between the number of non-tariff measures of the same type on a given product in the exporting and the importing country. It takes values between 0 and 1. A value equal to one corresponds the case when the two countries apply totally different types of NTMs (total dissimilarity), while a value equal to zero reflects the situation when countries apply exactly the same number of NTMs of each type. We compute regulatory distances for each type of NTM within the six most-commonly-used broad categories of NTM which account for 78.5% of the data on NTM (see Table 3). NTMs data are not well documented before 2012. Therefore, in estimations we use data starting from 2012.

The regulatory distance for SPS and TBT measures (types A and B) are highly correlated with each other. Therefore, we take the average of the two measures for each trade pair. The regulatory distances for contingent trade-protective NTMs (type D) are very close to zero for all country pairs. The regulatory distance for price-control NTMs (type F) are highly correlated with regulatory distances for other types of NTMs. For these reasons, we drop these two regulatory distances from our analysis.

Due to data limitation on tariffs and non-tariff measures, as well as for computational convenience, we consider only trade between the world's largest exporters and importers of agri-food products. Solving the structural gravity requires a full trade matrix and associated trade costs. To keep in the analysis some large countries that report few data on

6. United Nations Conference on Trade and Development
7. Trade Analysis INformation System

import duties, missing tariff data were filled in by extrapolating the existing data. Still, we cannot overcome the absence of NTMs data for some important exporters (*e.g.* Norway and Egypt) without making arbitrary or unrealistic assumptions. Therefore, we excluded from our analysis countries that do not report any NTMs data. Our final data panel contains the full trade matrix of 57 exporting and importing countries (Table A1 of the Appendix). The data panel accounts for 76%–77% of the global trade in the agri-food sector from 2012 to 2015. It covers 84%–85% of the selected countries' annual exports and 91%–92% of their annual imports of agricultural and food products to/from all partner countries.

We run the analysis on the entire agri-food sector and on 13 constituent groups of products. To obtain import tariffs and NTM regulatory distances at this level of aggregation, we take the average of values at the HS6 level, weighted by the global trade in each HS6 product. Table 4 provides descriptive statistics on import tariffs and regulatory distances used in aggregate-level estimations, for different types of trade flows. The product groups and their representation in our data panel are listed in Table 5.

Table 3: Different types of NTMs

	NTMs type	Government bodies potentially responsible
A	Sanitary and Phytosanitary (SPS) measures	Ministry of agriculture; Standardization Agency; Ministry of Health
B	Technical Barriers to Trade (TBT) measures	Standardization Agency; Ministry of Health; Ministry of Ecology; Ministry of Industry
C	Pre-Shipment inspection and other formalities	Customs Agency; Standardization Agency
D	Contingent trade-protective measures	Ministry of Finance; Ministry of Economy or Trade
E	Non-automatic licensing, quotas, prohibitions and other quantity control measures	Ministry of Economy (or Trade, Foreign Relations)
F	Price control measures including additional taxes and charges	Ministry of Economy (or Trade, Foreign Relations); Customs Agency

Source: "Guidelines to collect data on official non-tariff measures", January 2016 version, UNCTAD.

Table 4: Descriptive statistics for the aggregate agri-food sector (international trade only)

	Nb obs	Import tariff (%)		Regulatory distance for SPS-and-TBT NTMs (types A and B)		Regulatory distance for pre-shipment NTMs (type C)		Regulatory distance for quantity-control NTMs (type E)	
		mean	median	mean	median	mean	median	mean	median
Intra-EU	1,848	0.00	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
EU to third	3,080	16.42	14.18	0.2145	0.2059	0.0944	0.0588	0.0162	0.0088
Third to EU	3,080	12.11	12.87	0.2145	0.2059	0.0944	0.0588	0.0162	0.0088
Third to third	4,760	13.70	11.13	0.1845	0.1744	0.1521	0.1333	0.0171	0.0075

Note: Descriptive statistics based on the full sample (57 countries' trade with each other) over 2012-2015. International trade flows only.

Table 5: Product groups (2015 data)

Product Group	Global trade (bn $)	Share of data panel in global trade (%)	Data panel - share of the product group in			
			Total trade (%)	EU exports (%)	UK imports (%)	EU exports to the UK (%)
Meat & meat products	158	81.5	12.20	12.05	12.00	11.91
Dairy	81	78.7	6.01	5.68	5.97	5.74
Fish & sea products	119	73.0	8.20	8.45	8.32	8.50
Vegetables	92	80.4	6.96	6.92	6.85	6.81
Fruit	138	78.8	10.27	10.50	10.25	10.45
Cereals & cereal products	193	66.9	12.20	12.19	12.26	12.23
Oilseeds & vegetable oils	182	77.3	13.30	13.87	13.65	14.00
Coffee, spices, cocoa, sugar	149	70.6	9.86	9.90	9.86	9.89
Non-alcoholic beverages	20	75.5	1.44	1.38	1.40	1.36
Wines	32	90.5	2.77	2.61	2.58	2.51
Other alcoholic beverages	49	85.3	3.96	3.80	3.96	3.86
Tobacco	39	65.8	2.41	2.34	2.47	2.42
Other products	135	82.5	10.43	10.31	10.42	10.33
Total	1 388	76.4	100.00	100.00	100.00	100.00

4 Results at the aggregate level

Table 6 presents the PPML estimates of gravity parameters for the agri-food sector of the 57 main trading countries. Estimates are run for the entire panel 2012-2015. For our estimation strategy, we choose the USA as reference country. Accordingly, the inward multilateral remoteness term of this country is normalized to one: $P_{USA}= 1$ for all years and product groups. This choice stems from the fact that the USA are an important trade partner for any country in our data panel, including the United Kingdom, but only marginally affected by Brexit. Another aspect that supports our choice is the fact the USA have the most balanced trade in agri-food products in our panel of 57 countries.

We estimate domestic trade (X_{iit}) according to equation (7) and using importer and exporter fixed effects estimated with observed international trade data. Results of estimating equation (5) on international trade flows (with omitted fixed effects for the USA) are reported in column (1) of Table 6. Running the estimation on the full trade matrix with both domestic and international flows (column (2)) yields very small adjustments in the value of parameters. The effect of traditional gravity variables is in line with the empirical trade literature. Bilateral trade decreases with distance and import tariffs and is stronger for countries sharing a common land border, language, or colonial past. The presence of very different pre-shipment and quantity-control NTMs in the two trading countries (large regulatory distance for type C and type E NTMs) also deter trade. The estimated effect of discrepancies in countries' sanitary and phytosanitary standards and technical barriers is not significantly different from zero. When we set $\sigma = 5$ or above, a necessary condition

for estimating the counterfactuals for each of the five scenarios, we obtain a small positive effect. This result suggests that for our panel the informational role of SPS and TBT (trade-enhancing) outweighs their perception as barriers to trade.

Table 6: PPML estimates of trade cost parameters, aggregate agri-food sector

	Estimate σ		Set $\sigma = 5$
	International trade flows	Domestic & int'l trade flows	Domestic & int'l trade flows
	(1)	(2)	(3)
ln geographic distance	-0.82***	-0.82***	-0.79***
	(0.04)	(0.02)	(0.02)
common land border	0.48***	0.48***	0.46***
	(0.08)	(0.06)	(0.06)
common language	0.23***	0.23***	0.21***
	(0.09)	(0.08)	(0.08)
common colonial ties	0.67***	0.67***	0.75***
	(0.26)	(0.23)	(0.24)
ln (1 + tariff/100)	-1.77***	-1.76***	-4.00
	(0.66)	(0.46)	
regulatory distance SPS-and-TBT NTMs	-0.21	-0.20	0.58*
	(0.89)	(0.42)	(0.34)
regulatory distance pre-shipment NTMs	-1.54***	-1.49***	-1.75***
	(0.84)	(0.36)	(0.36)
regulatory distance quantity-control NTMs	-30.91***	-31.76***	-30.99***
	(9.45)	(2.40)	(2.34)
Fixed effects	it , jt	it , jt	it , jt
Nb observations	12,553	12,996	12,996
R^2	0.842	0.917	0.896

Note: Estimations based on the full trade matrix between the 57 countries in our data panel over 2012-2015. ***, ** and * indicate statistically significance at the 1%, 5%, and respectively 10%.

Using estimation results from Table 6 and the methodology outlined in section 3.2, we estimate the direct and indirect effects of a change in trade costs. Table 7 reports the estimated impacts in a general equilibrium framework for the aggregate agri-food sector for an elasticity of substitution σ equal to 5.[8] Estimated impacts for each of the five scenarios described in Tables 1 and 2 and discussed in section 2.2 are reported. Among our sample of 57 trade partners we focus on the impacts for the UK and its main EU partners (Netherlands, Ireland, France, Germany, Spain, Belgium-Luxembourg and Italy),[9] as well as for its main non-EU trade partners. The latter comprise six countries with which the UK is assumed to

8. The model does not converge for the estimated value of the elasticity of substitution: $\sigma = 2.76$. The smallest value for which the model converges under all five scenarios is $\sigma = 5$. We obtain very similar results for alternative values $\sigma = 6$ and $\sigma = 7$. These results can be provided upon request.

9. The UK's trade with each of these countries accounted on average for at least 5% its total trade (exports + imports) in the agricultural and food sector over the 2012-2015 period.

conclude PTA in scenarios S3 and S4 (USA, Australia, New Zealand, Chile, Israel, and Switzerland) and other six countries with which the UK trades the most (China, Brazil, Thailand, India, Canada, and Argentina). We also report average impacts for the European Union.[10] For each country, we display the percentage change in imports and exports at the global level and bilateral with the UK, as well as the change in the factory gate price of domestic producers and in the price-adjusted revenue. To understand the mechanisms behind some of these results, we also list changes in the average price of products sold in the country (IMR), and in the average price of domestic products sold worldwide (OMR).[11]

We focus not only on the direct changes in the trade flows for which we assume a change in trade costs, but also on the indirect impact of these changes on other trade flows via adjustments in price indices, expenditure and output levels. A change in trade costs for a given bilateral relationship affects the average price faced by consumers in the importing country, with a potential impact on the competitiveness of products sold in this market. Thus, if the UK's post-Brexit trade policy leads to an increase (decrease) in the average price of products purchased by UK consumers, goods for which the price remain unchanged appear as more (less) competitive since they are now compared to a higher (lower) reference value. These changes in relative prices will lead to a reallocation of consumers' demand across products of different origins. Similarly, changes in global trade patterns affect producers' revenues in exporting countries. Thus, if non-EU countries' overall exports (to all destinations) increase after Brexit, the revenues of these countries will also increase, with a larger amount to be spent on all products, including on imports from EU countries. The general equilibrium framework of the structural gravity model permits to account for direct effects (changes in trade costs of concerned flows), as well as for indirect effects (changes in trade costs between other partners and worldwide adjustments in terms of price indices, supply and demand) on global trade patterns.

Recall that scenarios S1 and S3 assume an EU-UK agreement similar to a CETA+, while scenarios S2 and S4 assume MFN tariffs between the UK and the EU. In scenarios S1 and S3, the UK continues its commitments towards third countries, made when the UK was still an EU member. Under scenarios S2 and S4, the UK negotiates PTA with its main non-EU partners and introduces MFN rules for trade with other third countries. Finally, the unilateral liberalization of the UK's market under scenario S5 is closely associated to the temporary tariffs the British government intends to introduce in case of no-deal Brexit. In the absence of comparable data on output or expenditure at sector (and product level) for

10. Our data panel includes only 22 EU countries other than the UK. Malta, Cyprus, Slovenia, Croatia, and Estonia are not excluded because of the small size of their economy and/or limited number of trade partners. Belgium and Luxembourg are aggregated under a single observation. Effects for the EU are obtained as a weighted average of effects for the EU countries in the data panel, using the countries' share in global trade as weights.

11. Effects on nominal expenditure and output are very close to effects on factory gate prices and are, therefore, omitted.

all countries in the panel,[12] we estimate domestic trade (X_{iit}) according to equation (7) and using importer and exporter fixed effects estimated with observed international trade data.

Based on simulation results displayed in Tables 7 and A2, we draw the following main conclusions:

- The five scenarios imply a decline in EU imports and exports, and real income.
- Within the EU, Ireland is the most severely affected.
- The effects on the British economy are significantly larger than on the EU, under all scenarios.
- All scenarios have a negative effect on the UK. Losses are smaller if a deep EU-UK FTA is concluded, the UK negotiates PTA with six main non-EU trade partners, and the UK's trade with other non-EU countries takes place under WTO terms (scenario S3). The unilateral liberalization of the British market (scenario S5) is not an optimal outcome for the UK, although it yields smaller losses than an exit with no EU-UK trade deal and the return to MFN tariff rates. This scenario also produces the largest drop in the nominal revenue of British agri-food sector.
- Effects are quite heterogeneous across third (non-EU) countries, both among the ones with which the UK is most likely to sign PTA and the rest.

Effects on the EU

For the EU, scenario S1 (the closest to the *status quo*) yields the smallest decrease in trade flows (especially EU-UK trade) and real income, while the scenarios implying a Brexit with no EU-UK trade deal (S2 and S4) are the most harmful. Still, the size of effects remains small under all scenarios. The real income of EU consumers decreases under all scenarios, although it never exceeds 1%. Similarly, we observe a decrease in the overall exports and imports of EU countries in all five scenarios, the effect being the largest (2.2%-2.3%) under scenario S2. In this case, the increase in EU-UK trade costs deteriorates the access of European goods to the global market: their average price index to consumers in the destination country (OMR) increases by 0.1%-1.5%. The average price of goods sold on the EU market (IMR) decreases slightly (by 0.04%-0.54%). While scenarios with no EU-UK trade deal (S2 and S4) generate a relatively small drop in EU's overall exports and imports (-0.7% to -2.3%), the effect on bilateral EU-UK trade may get quite large: -30% to -37%. To reach balanced trade, as imposed by the model, European producers need to sell their products at lower prices, the effect being the strongest under scenarios S4 (-1.2%) and S5 (-1%).

12. One can compute domestic trade as domestic output minus exports, or domestic expenditure minus imports.

Table 7: The effects of different Brexit scenarios on the aggregate agri-food sector

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-2.55	-12.85	0.22	-8.40	-7.67	-4.30	-23.27	-0.08	-16.34	-9.04
Netherlands	-0.45	-3.11	-0.42	-1.83	-0.93	-0.46	-3.00	-0.27	-1.24	-0.66
Ireland	-0.79	-4.95	-0.80	-3.84	-2.82	-0.77	-4.45	-0.60	-2.86	-2.07
France	-0.32	-2.33	-0.23	-1.00	-0.34	-0.36	-2.38	-0.15	-0.73	-0.27
Germany	-0.29	-2.19	-0.19	-0.81	-0.17	-0.35	-2.36	-0.14	-0.66	-0.21
Spain	-0.30	-2.21	-0.24	-0.95	-0.29	-0.33	-2.21	-0.13	-0.65	-0.22
Belgium-Lux.	-0.30	-2.26	-0.17	-0.81	-0.17	-0.35	-2.40	-0.10	-0.59	-0.16
Italy	-0.26	-1.99	-0.18	-0.67	-0.06	-0.31	-2.13	-0.13	-0.56	-0.13
EU	-0.30	-2.22	-0.21	-0.89	-0.25	-0.34	-2.31	-0.14	-0.67	-0.22
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	-6.97	-34.94	-11.31	-37.15	-22.92	-5.09	-30.60	-6.22	-30.83	-24.72
Ireland	-6.45	-33.03	-10.26	-34.99	-21.71	-4.36	-27.01	-5.24	-27.13	-21.62
France	-6.91	-34.59	-11.22	-36.75	-22.54	-5.09	-30.68	-6.21	-31.01	-24.93
Germany	-6.97	-34.85	-11.32	-37.05	-22.76	-5.15	-30.93	-6.30	-31.24	-25.10
Spain	-6.91	-34.46	-11.25	-36.63	-22.33	-5.13	-30.93	-6.29	-31.37	-25.27
Belgium-Lux.	-7.00	-35.05	-11.36	-37.27	-23.01	-5.12	-30.74	-6.26	-30.97	-24.83
Italy	-6.93	-34.55	-11.28	-36.72	-22.40	-5.17	-31.11	-6.32	-31.52	-25.40
EU	-6.92	-34.62	-11.25	-36.79	-22.53	-5.12	-30.83	-6.26	-31.19	-25.08
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	1.43	9.49	0.68	8.68	-3.84	1.09	3.37	-0.35	2.21	8.73
Netherlands	-0.05	-0.64	-0.06	-0.49	-0.39	0.12	1.06	0.31	1.62	1.37
Ireland	0.14	0.40	0.30	0.68	0.25	0.36	2.67	0.63	3.29	2.66
France	-0.03	-0.52	-0.03	-0.35	-0.28	0.12	1.03	0.31	1.54	1.29
Germany	-0.05	-0.64	-0.07	-0.49	-0.37	0.10	0.91	0.28	1.43	1.21
Spain	-0.03	-0.49	-0.04	-0.34	-0.24	0.10	0.91	0.28	1.37	1.14
Belgium-Lux.	-0.05	-0.70	-0.07	-0.55	-0.43	0.11	1.00	0.29	1.56	1.33
Italy	-0.04	-0.54	-0.05	-0.39	-0.28	0.09	0.83	0.27	1.30	1.09
EU	-0.04	-0.54	-0.04	-0.38	-0.29	0.11	0.96	0.29	1.45	1.22
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-0.86	-2.62	0.28	-1.73	-6.48	-2.26	-11.06	-0.40	-9.58	-2.74
Netherlands	-0.09	-0.84	-0.25	-1.27	-1.09	-0.05	-0.20	-0.19	-0.78	-0.70
Ireland	-0.28	-2.09	-0.50	-2.56	-2.08	-0.42	-2.47	-0.80	-3.21	-2.33
France	-0.09	-0.81	-0.25	-1.21	-1.02	-0.06	-0.30	-0.22	-0.86	-0.74
Germany	-0.08	-0.72	-0.22	-1.13	-0.96	-0.03	-0.09	-0.16	-0.64	-0.59
Spain	-0.08	-0.72	-0.23	-1.08	-0.91	-0.05	-0.24	-0.18	-0.75	-0.67
Belgium-Lux.	-0.09	-0.79	-0.23	-1.23	-1.05	-0.03	-0.10	-0.16	-0.68	-0.63
Italy	-0.07	-0.66	-0.22	-1.03	-0.86	-0.03	-0.12	-0.16	-0.64	-0.59
EU	-0.09	-0.76	-0.23	-1.15	-0.97	-0.05	-0.22	-0.19	-0.76	-0.67

Source: Computations by authors.

Notes: Five post-Brexit trade policy scenarios considered: (S1) EU-UK FTA & the UK replicates EU's PTA with third countries; (S2) No EU-UK trade deal & the UK replicates the EU's PTA with third countries; (S3) EU-UK FTA & the UK signs PTA with six main third trade partners; (S4) No EU-UK trade deal & the UK signs PTA with six main third trade partners; (S5) Unilateral liberalization of the British market.

Within the EU, Ireland is the most impacted country. Under all scenarios, Ireland loses the most in terms of real income, overall exports and imports, and access to the global market (OMR). It is also the only EU country for which the average price of domestic and imported products increases (positive IMR).

Effects on the UK

Results in Table 7 show that scenario S3 (a trade deal with the EU and PTA with main third partners) should be preferred by the UK. The other policy options produce a stronger contraction of British exports and imports and/or of the real income of British consumers. The country's exit from the EU with no trade deal (scenarios S2 and S4) generates the largest losses. It also leads to a significant increase in the price of goods (both domestic and foreign) sold to British consumers: a 8.7%-9.5% growth of the UKs' inward multilateral resistance. This effect comes both from the higher price of EU products (which will be charged high MFN tariff rates when imported into the UK), as well as from the switch to more distant alternative source countries (subject to larger transport costs, some also subject to import tariffs). In the end, the real income of British consumers would drop by 9.6%-11% under scenarios S2 and S4.

A unilateral liberalization by the UK of its domestic market produces intermediate size effects. It does not represent an optimal solution, as suggested by some British politicians. The drop in the real income of British consumers is larger under scenario S5 (unilateral liberalization) than under scenario S1 (continuation of current trade relationships = FTA with the EU and replication of EU trade agreements with third countries). In addition, scenario S5 generates a stronger contraction of British exports and imports (both worldwide and with the EU) than S2. Scenario S5 produces the largest increase (8.7%) in the average price of British products on the global market (OMR), constraining British producers to charge their products 6.5% less in order to balance their trade (vs. < 3% under other scenarios).

A unilateral liberalization of the British market (scenario S5) is not the best outcome for the UK since it would lead to 7.7% drop in its imports and a 9% in its exports. The UK's trade with the EU would contract even more, by as much as 25% of its pre-Brexit level. Unlike other scenarios that make imported products more expensive, this policy would have the opposite effect, predictions showing a 4% drop in the price of products that reach the UK market. However, scenario S5 generates the highest increase in the price of British products sold worldwide (+8.7%).

Effects on third countries

The effects of different scenarios on the UK's main non-EU trade partners with which it is most likely to conclude PTA (USA, Australia, New Zealand, Chile, Israel, Switzerland) and

its other important third partners are displayed in Table A2. Results are very differentiated across countries. As in the case of the EU, results in terms of real income are quite small in magnitude (<1%). Among countries more likely to conclude a PTA with the UK, the effect in terms of real income is the largest for Switzerland (+0.8% under S3; +1.1% under S4). Except for Switzerland, all the countries within this group suffer small loss in their real income under scenario S5. With one small exception (Israel, S5), the six countries increase their trade with the UK under all scenarios. In some cases, effects are very large: over a twofold increase in trade flows for some of these countries under scenarios S3 and S4. The change in these countries' total exports and imports is smaller, but always positive under scenarios S3, S4, and S5. The effects on other non-EU countries that count among the UK's main trading partners are very small in magnitude and show insignificant variation across scenarios.

5 Effects by groups of products

When computing the effects of the five scenarios, we let the elasticity of substitution vary across product groups. For seven groups, we use the estimated value of σ, convergence being reached under all scenarios. For the remaining six groups, the estimated value of σ is very low or statistically non significant, and we set it equal to the smallest positive integer greater than one for which convergence is reached under all scenarios. Table 8 resumes the estimated and used values of elasticity of substitution for each product group.

Table 8: Elasticity of substitution values

Product group	Estimated σ	Used σ	
Meat & meat products	1.54	5.00	set
Dairy	3.59 ***	3.60	estimated
Fish & sea products	0.10	3.00	set
Vegetables	7.18 ***	7.20	estimated
Fruit	7.29 ***	7.30	estimated
Cereals & cereal products	1.48	4.00	set
Oilseeds & vegetable oils	-2.04 ***	3.00	set
Coffee, spices, cocoa, sugar	5.21 ***	5.20	estimated
Non-alcoholic beverages	3.60 **	3.60	estimated
Wines	2.46	2.50	estimated
Other alcoholic beverages	0.40	7.00	set
Tobacco	3.39 ***	3.40	estimated
Other products	2.38 **	3.00	set
Entire agri-food sector	2.76 ***	5.00	set

Note: Estimations based on the full trade matrix between the 57 countries over 2012-2015. ***, ** and * indicate statistically significance at the 1%, 5%, and respectively 10%.

Estimation results by groups of products with the estimated value of σ are reported in Table A3 of the Appendix. We see a great variation in the statistical significance and the magnitude of estimated effects across product groups. We obtain counter-intuitive significant effects mainly for products subject to excise duties (*''Tobacco''*, *''Wines''* and *''Other alcoholic beverages''*).[13] Cross-country differences in the level of excise duties or in other types of regulations aiming to reduce the consumption of these products often outweigh the trade cost advantage induced by geographic proximity, historical ties, and/or similar levels of NTM protection. Unsurprisingly, some effects opposite to results usually found in the literature are also obtained for the highly heterogeneous group *''Other products''*. Indeed, in a highly heterogeneous group parameter estimates, including trade elasticity, vary greatly across products, while the estimation imposes, the same estimated value of each parameter for all products in the group.

Setting σ to a value different from the estimated one, as listed in Table 8, only marginally affects the magnitude and the statistical significance of most estimated effects (Table A4 of the Appendix.). The most sizable changes are the increase in the magnitude of effects of regulatory distances for *''Meat & meat products''*, *''Oilseeds & vegetable oils''*, *''Wines''*, and *''Other alcoholic beverages''*, with some of these effects becoming statistically significant. Accordingly, the simulation results for these product groups should be interpreted with some reservation, privileging the sign and the relative evolution of effects rather than actual figures.

The regulatory distances for the tree types of NTMs included in the model have mainly a negative effect on trade flows. Still, our estimates show that an increase in the SPS-and-TBT regulatory distance leads to an increase in the volume of trade in *''Meat & meat products''* and in *''Coffee, spices, cocoa, sugar''*. Although a different number of SPS and TBT in two countries does not necessarily reflect a difference in the content or stringency of their norms, this is very unlikely to be the case for each country pair and product. Therefore, we can interpret the above-mentioned result as evidence of the fact that, SPS and TBT, unlike other NTM, are perceived by foreign competitors not only as barriers to trade, but also as informative measures that provide details on some important market entry conditions.

Detailed simulation results by groups of products are reported in Table A5 of the Appendix. For most product groups, the failure of the UK and the EU to negotiate a trade agreement granting free or nearly free access of their goods to each other's market would lead to a

13. We find a positive effect of regulatory distances computed for pre-shipment NTMs and/or quantity-control NTMs for the three product groups, a negative effect of common land border on trade in *''Tobacco''*, and a negative effect of colonial ties on trade in *''Other alcoholic beverages''*. We explain these findings by the fact that countries with close bilateral ties and similar levels of NTMs protection also tend to apply similar level of excise duties. While the former reduce bilateral trade costs, the latter have the opposite effect and encourage countries to search for more dissimilar trade partners. When the second effect dominates, we obtain counter-intuitive effects of trade cost variables.

significant drop in British and European trade with all partners, and particularly strong in mutual (EU-UK) trade. This result holds even if the UK opens its market to all trade partners (unilateral liberalization), effects being of similar magnitude. As for the aggregate agri-food sector, negative effects are considerably large for the UK than for EU countries. Scenarios assuming the conclusion of an EU-UK trade deal generally yield very small variations in the volume of trade.

The European *''Meat & meat products''* sector appears to suffer the most from Brexit if no EU-UK trade deal is reached (scenarios S2 and S4). Overall EU exports in this product group would drop by 5.7%-8.5%, while EU exports to the UK would shrink by a third. However, results for this group of products and five more are obtained with a higher value of σ than the estimated one,[14] and therefore need to be used with caution.[15] Rather than focus on actual figures, the interpretation of results for these groups of products should rely on comparing effects across countries and scenarios (and less with other groups of products). Ireland is particularly vulnerable in this sector: it registers the strongest decrease in global trade within the EU (comparable to that the UK) and the lowest decrease in exports to the UK.[16] This result is induced by the strong interconnection of Irish producers with British value chains and their increased difficulty to access the EU and extra-EU markets.[17]

The absence of a post-Brexit EU-UK trade agreement will also have a strong impact on EU exports in product groups *''Fruit''* and *''Vegetables''*. Our results show a 1.2%-1.6% drop in EU exports worldwide and a 21%-32% contraction of EU exports to the British market in case of a no-deal Brexit. Product groups *''Fruit''* and *''Vegetables''* also show the largest drop in European exports under the scenario of a unilateral liberalization of the British market: 2.4%-2.8% for EU global exports and 19%-26% for EU exports to the UK.

Effects on the British agri-food sector also differ greatly across groups of products. We find the largest drop in British exports under scenarios with no EU-UK deal, in product groups *''Vegetables''* (-46%-49%), *''Meat & meat products''* (-43%-49%), *''Dairy''* (-29%-32%), and *''Fruit''* (-27%-29%). Opening the domestic market to foreign competition (the 'Liberalized UK' scenario) yields a comparable contraction of British trade, although somewhat smaller in magnitude. Should the UK conclude a FTA with the EU and PTA with its main non-EU partners (scenario S3), results suggest an increase in British exports in all sectors except

14. *''Fish & sea products''*; *''Cereals & cereal products''*; *''Oilseeds & vegetable oils''*; *''Other alcoholic beverages''*; *''Other products''*. Estimations yield a non-significant or aberrant value of σ for these groups. For the last group, only a larger value of σ ensures the convergence of counterfactual estimates for scenario S5.
15. Using a larger σ amplifies the effects of different scenarios, especially the large positive and negative effects.
16. We obtain similar findings for Ireland in the *''Dairy''*, *''Fish & sea products''*, *''Cereal & cereal products''*, *''Coffee, spices, cocoa, sugar''*, *''Non-alcoholic beverages''*; contrasts with other EU countries are much smaller for the rest of products.
17. The geographical position of Ireland strongly penalizes the reorientation of Irish exports of meat and meat products that require quick transportation in refrigerated containers and undergo a large number of border checks and controls.

''Meat & meat products'', *''Dairy''*, and *''Fish & sea products''*. Still, the magnitude of effects varies significantly from less than 1% for *''Wines''* to nearly 7% for *''Other alcoholic beverages''*.

Results indicate that introducing regulatory checks on the EU-UK border and keeping other trade relationships unaltered (scenario S1) has sizable effect only on trade in *''Meat & meat products''*, *''Dairy''*, *''Fish & sea products''*, and *''Tobacco''*, *i.e.* the products subject to a large number of border sanitary and food safety controls and NTM.

We also computed the changes induced by the five scenarios for each product group by ignoring the effect of non-significant variables, *i.e.* using parameter estimates displayed in Table A4 of the Appendix.[18] Recall we define our trade policy scenarios as a change in import tariffs and in the regulatory distance of pre-shipment NTM. Therefore, dropping out non-significant effects leads to a decrease in the magnitude of simulated effects on trade for the five product groups for which the estimated parameter of the regulatory distance of pre-shipment NTM was statistically non-significant (in Table A3): *''Dairy''*, *''Fish & sea products''*, *''Vegetables''*, *''Fruit''*, and *''Coffee, spices, cocoa, sugar''*. More specifically, for these product groups, scenario S1 becomes pointless as all effects cancel out for all trade flows, scenarios S3 and S5 account only for indirect effects on EU countries, while scenario S2 accounts only for indirect effects on third (non-EU) countries. Still, the main conclusions discussed above remain unaltered.

6 Conclusion and further work

Brexit marks a turning point in the history of economic integration across Europe and raises many questions on future trade relationship between the United Kingdom and the European Union. The EU agri-food sector is strongly internationalized and trade flows with the UK represent a high percentage (9.4% of exports in 2016) of total European trade flows. Therefore, it is important to evaluate the challenges and potential risks faced by different producers, and draw some guidance for the EU-UK trade negotiations. The current paper aims to measure the potential effects induced by Brexit in the agricultural and food sector, both at country-level and for specific bilateral trade relationships. We consider five scenarios for the UK's trade policy with EU and third countries after its exit from the European Union. These include a EU-UK deep free trade agreement or an exit with no EU-UK trade deal, the continuation of the UK's trade commitments towards third partners made when the UK was still member of the EU or the negotiation of new preferential trade

18. These results can be provided upon request.

agreements with main non-EU partners, and the unilateral liberalization of the British market.

We use a structural gravity model to estimate the effects of Brexit on EU countries under each trade policy scenarios. We use data on annual bilateral agri-food trade flows over the four years preceding the Brexit vote (2012-2015). This permits to eliminate any bias induced by the global economic slowdown during the 2008 financial crisis and the subsequent recovery, by the dramatic worldwide increases in food prices in the late 2007, or by the announcement of Brexit vote results in mid-2016. Our data panel is composed of the world's largest 57 exporters and importers of agri-food products and covers 75% of global trade in these goods. We use a trade costs structure combining tariffs, non-tariff measures, geographic distance, and standard variables on bilateral linkages between trading countries used in the literature. Each scenario is defined as a change in import tariffs and non-tariff measures on the EU-UK bilateral trade and on British imports from third (non-EU) countries.

Our results show that under all scenarios the British agri-food sector suffers economic losses. In relative terms (expressed as a percentage change), the latter are considerably stronger than the losses incurred by the EU as a group and by individual EU countries. Unsurprisingly, the EU is less affected if Brexit is followed by the conclusion of an EU-UK free trade agreement. This scenario also generates the smallest contraction of the British economy.

In case of an exit with no deal, the negative effects on the EU's real income, as well as on EU's global agricultural exports and imports, are attenuated if the UK continues to apply the EU preferential trade agreements with third countries. European authorities should thus encourage the British government to pursue its commitments towards third countries that were in place before Brexit.

Besides, all scenarios suggest that Brexit will generate a decrease in the average price of goods sold on the EU market, except for Ireland. Our results show that the losses suffered by Ireland are largely compensated by the competitiveness gains of other EU countries. Hence, setting up a mutual European fund to smooth the effects of Brexit across EU countries appears as a viable strategy.

Finally, we observe that the negative impacts on the British economy are smaller when the UK and the EU reach a trade deal. The unilateral liberalization scenario is not the optimal solution, since it generates a large decrease in the income of British consumers. This scenario also yields a similar effect on the UK's trade worldwide and with the EU.

Appendices

Table A1: List of countries in the data sample (2015 data)

Country	Global trade		Selected data panel				Share data panel in global trade	
	Exports	Imports	Exports		Imports		Exports	Imports
	bn $	bn $	bn $	%	bn $	%	%	%
Argentina	35.4	1.8	27.5	*2.60*	1.7	*0.16*	77.9	92.4
Australia	33.7	13.5	27.8	*2.62*	12.8	*1.21*	82.5	94.8
Austria	11.2	12.5	10.0	*0.94*	11.9	*1.12*	89.3	95.1
Belgium-Luxembourg	35.9	36.8	33.4	*3.15*	34.1	*3.22*	93.1	92.7
Brazil	75.8	9.4	60.0	*5.65*	8.5	*0.81*	79.1	90.6
Bulgaria	4.2	3.0	3.5	*0.33*	2.7	*0.25*	81.8	89.8
Canada	49.5	35.2	45.5	*4.29*	34.0	*3.21*	91.9	96.7
Chile	17.1	5.8	15.8	*1.49*	5.0	*0.47*	92.5	85.8
China	56.1	126.4	46.4	*4.38*	118.0	*11.12*	82.8	93.3
Colombia	7.3	5.5	6.5	*0.62*	4.8	*0.46*	90.3	88.3
Costa Rica	5.3	1.7	4.5	*0.42*	1.5	*0.14*	84.6	87.4
Czech Rep.	7.4	9.0	6.9	*0.65*	8.6	*0.81*	94.3	96.1
Denmark	19.3	12.4	17.3	*1.63*	11.2	*1.05*	89.6	90.3
Ecuador	10.0	1.9	9.0	*0.85*	1.6	*0.15*	90.6	86.5
Finland	1.8	5.4	1.5	*0.14*	4.8	*0.46*	82.4	89.3
France	67.7	54.5	60.1	*5.67*	49.8	*4.69*	88.8	91.4
Germany	76.6	87.7	70.0	*6.60*	82.6	*7.78*	91.5	94.1
Greece	6.0	6.8	5.1	*0.48*	6.2	*0.59*	84.7	90.9
Guatemala	5.6	2.5	4.5	*0.42*	2.1	*0.20*	79.6	84.7
Honduras	2.8	1.5	2.4	*0.23*	1.2	*0.12*	87.8	83.9
Hungary	8.5	5.1	7.4	*0.69*	4.7	*0.45*	87.1	92.3
India	31.8	20.5	20.9	*1.97*	15.8	*1.49*	65.5	77.3
Indonesia	35.7	14.3	29.8	*2.81*	13.6	*1.28*	83.5	95.3
Ireland	15.8	9.3	14.7	*1.39*	9.0	*0.85*	93.4	97.2
Israel	3.3	6.2	2.2	*0.21*	5.0	*0.47*	66.9	80.1
Italy	41.3	45.2	37.4	*3.52*	41.2	*3.88*	90.4	91.0
Japan	5.3	61.1	4.7	*0.45*	56.4	*5.32*	89.6	92.2
Kazakhstan	2.2	3.4	0.7	*0.06*	2.4	*0.22*	29.6	69.6
Latvia	2.1	2.2	1.6	*0.15*	1.9	*0.18*	76.8	87.3
Lithuania	5.0	4.0	3.9	*0.37*	3.5	*0.33*	78.4	87.7
Malaysia	22.9	15.6	18.3	*1.73*	14.3	*1.35*	80.0	91.7
Mexico	30.0	24.4	28.6	*2.70*	23.9	*2.25*	95.5	98.0
Morocco	5.8	4.2	4.7	*0.45*	3.7	*0.35*	81.6	89.1
Myanmar	2.7	3.1	2.5	*0.23*	3.1	*0.29*	92.8	97.8
Netherlands	78.2	60.7	72.6	*6.85*	54.1	*5.10*	92.8	89.2
New Zealand	21.5	4.1	18.4	*1.74*	3.9	*0.37*	85.6	95.1
Nigeria	1.4	5.0	1.5	*0.15*	4.6	*0.43*	112.6	90.3
Pakistan	5.5	5.6	2.7	*0.25*	4.6	*0.43*	48.6	82.6
Peru	8.1	4.2	7.5	*0.70*	3.7	*0.35*	92.1	87.8
Philippines	7.0	9.4	6.1	*0.57*	9.0	*0.85*	87.2	95.5

Table A1: List of countries in the data sample (2015 data), continued

Country	Global trade		Selected data panel				Share data panel in global trade	
	Exports	Imports	Exports		Imports		Exports	Imports
	bn $	bn $	bn $	%	bn $	%	%	%
Poland	26.0	17.7	23.0	*2.17*	15.6	*1.47*	88.6	87.7
Portugal	6.8	10.6	5.8	*0.54*	9.5	*0.90*	84.4	89.7
Romania	6.7	6.6	4.8	*0.45*	5.9	*0.56*	71.1	90.2
Russian Federation	17.9	26.0	9.2	*0.86*	17.9	*1.69*	51.2	68.9
Saudi Arabia	3.7	22.6	1.0	*0.10*	17.9	*1.69*	27.1	79.5
Singapore	8.2	12.6	7.2	*0.68*	11.9	*1.12*	88.2	94.4
Slovakia	2.8	4.5	2.7	*0.25*	4.3	*0.41*	95.9	96.0
Spain	47.0	35.2	42.8	*4.04*	31.1	*2.93*	91.2	88.4
Sweden	7.4	13.3	6.2	*0.58*	11.4	*1.07*	83.3	85.6
Switzerland	9.2	12.0	8.5	*0.80*	11.2	*1.06*	92.0	93.2
Thailand	31.1	13.0	25.4	*2.40*	11.6	*1.09*	81.7	89.1
Turkey	17.6	11.6	10.3	*0.97*	9.2	*0.87*	58.7	79.5
USA	138.2	137.3	120.1	*11.32*	128.8	*12.14*	86.9	93.8
United Arab Emirates	9.1	16.4	2.4	*0.22*	13.5	*1.27*	26.2	82.2
United Kingdom	29.5	63.6	26.5	*2.50*	59.0	*5.56*	89.7	92.7
Uruguay	4.3	1.3	3.5	*0.33*	1.2	*0.11*	83.1	91.4
Viet Nam	20.2	21.4	17.4	*1.64*	19.1	*1.80*	86.1	88.9
Total	1 248.1	1 166.8	1 060.7	*100.00*	1 060.7	*100.00*	85.0	90.9

Table A2: The effects of Brexit scenarios on the agri-food sector of non-EU countries (σ=5)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.05	0.14	1.09	2.46	2.01	0.03	0.03	0.92	1.98	1.42
Australia	0.00	-0.16	0.63	1.57	1.35	-0.02	-0.28	0.38	1.02	0.85
New Zealand	0.02	-0.04	0.49	1.52	1.70	-0.02	-0.26	0.20	0.73	0.80
Chile	0.01	-0.14	0.30	1.14	1.10	-0.04	-0.38	0.23	0.83	0.74
Israel	0.00	-0.21	0.45	1.39	0.74	0.03	0.08	0.79	1.75	0.35
Switzerland	0.00	-0.29	1.33	2.45	1.37	-0.03	-0.47	1.58	2.91	1.39
China	-0.02	-0.32	-0.09	0.55	1.11	0.03	0.03	-0.17	0.39	0.93
Brazil	0.06	0.17	0.06	1.08	1.84	-0.04	-0.39	0.07	0.61	0.92
Thailand	0.00	-0.20	0.14	0.76	1.00	-0.02	-0.30	0.08	0.47	0.62
India	0.01	-0.09	0.78	1.63	1.31	-0.01	-0.23	0.48	1.02	0.84
Canada	0.00	-0.17	0.26	1.08	1.32	-0.01	-0.25	0.15	0.75	0.96
Argentina	0.03	0.03	-0.16	0.66	1.53	-0.03	-0.39	0.03	0.51	0.81
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	3.49	10.87	23.46	34.89	32.12	4.87	39.49	57.84	108.85	60.13
Australia	3.48	10.74	24.71	36.09	31.87	4.90	39.79	70.19	125.61	57.78
New Zealand	3.50	10.90	3.81	13.45	32.36	4.91	39.86	46.63	94.52	65.64
Chile	3.53	11.05	6.59	16.36	31.82	4.84	39.33	28.76	70.68	23.21
Israel	3.39	10.06	42.73	54.59	29.85	4.92	40.05	29.90	72.90	-4.30
Switzerland	3.25	8.79	125.15	140.97	28.77	4.82	39.50	56.54	108.58	39.03
China	3.42	10.30	4.05	12.91	31.08	4.96	40.33	-12.02	17.27	40.33
Brazil	3.55	11.17	8.39	18.28	32.33	4.84	39.27	1.63	34.93	49.88
Thailand	3.47	10.63	141.05	161.95	31.41	4.94	40.14	-15.73	12.24	33.75
India	3.42	10.32	222.11	248.60	30.91	4.91	39.85	-13.10	15.73	37.47
Canada	3.49	10.89	24.13	35.47	32.19	4.87	39.48	10.92	47.34	55.17
Argentina	3.59	11.47	8.94	19.11	32.63	4.85	39.35	-7.36	23.00	43.05
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	-0.01	-0.10	0.05	0.19	0.22	-0.02	-0.11	-0.24	-0.41	-0.21
Australia	-0.01	-0.11	0.03	0.15	0.19	-0.01	-0.04	-0.17	-0.29	-0.13
New Zealand	0.00	-0.07	0.08	0.25	0.28	0.00	-0.03	-0.08	-0.17	-0.17
Chile	0.00	-0.06	-0.03	0.10	0.21	-0.02	-0.15	-0.08	-0.20	0.01
Israel	-0.03	-0.25	-0.14	-0.16	-0.10	0.00	0.01	0.11	0.12	0.32
Switzerland	-0.07	-0.57	-0.59	-0.92	-0.33	-0.03	-0.11	-0.29	-0.24	0.25
China	-0.02	-0.19	-0.08	-0.06	0.07	0.01	0.08	0.19	0.25	0.04
Brazil	0.00	-0.04	-0.06	0.09	0.27	-0.03	-0.16	0.11	0.04	-0.16
Thailand	-0.01	-0.12	-0.22	-0.16	0.14	0.00	0.04	0.26	0.30	0.03
India	-0.03	-0.20	-0.72	-0.77	0.04	-0.01	-0.03	0.40	0.44	0.02
Canada	-0.01	-0.09	0.08	0.24	0.24	-0.02	-0.11	-0.03	-0.14	-0.20
Argentina	0.01	0.03	-0.08	0.11	0.34	-0.02	-0.14	0.15	0.09	-0.11
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.01	0.09	0.19	0.33	0.17	0.02	0.18	0.14	0.13	-0.05
Australia	0.01	0.04	0.14	0.23	0.10	0.02	0.15	0.11	0.07	-0.09
New Zealand	0.00	0.02	0.06	0.14	0.13	0.01	0.09	-0.01	-0.11	-0.14
Chile	0.02	0.12	0.07	0.16	-0.01	0.02	0.18	0.10	0.05	-0.22
Israel	0.00	-0.01	-0.09	-0.10	-0.25	0.03	0.24	0.05	0.07	-0.15
Switzerland	0.02	0.09	0.23	0.19	-0.20	0.09	0.66	0.83	1.12	0.13
China	-0.01	-0.06	-0.15	-0.20	-0.03	0.01	0.13	-0.07	-0.14	-0.11
Brazil	0.02	0.13	-0.09	-0.03	0.13	0.02	0.17	-0.03	-0.13	-0.15
Thailand	0.00	-0.03	-0.21	-0.24	-0.02	0.01	0.09	0.01	-0.08	-0.16
India	0.00	0.02	-0.32	-0.35	-0.01	0.03	0.23	0.40	0.42	-0.05
Canada	0.01	0.09	0.02	0.11	0.16	0.02	0.18	-0.05	-0.12	-0.08
Argentina	0.02	0.11	-0.12	-0.08	0.09	0.00	0.08	-0.04	-0.19	-0.25

Notes: The six countries assumed to negotiate a PTA with the UK in S4 (shaded) and the next six important partners.

Table A3: The impact of different trade cost components on trade by groups of products

	Meat & meat products	Dairy	Fish & sea products	Vegetables	Fruit	Cereals & cereal products	Oilseeds & vegetable oils	Coffee, spices, cocoa, sugar	Non-alcoholic beverages	Wines	Other alcoholic beverages	Tobacco	Other products
ln geographic distance	-0.90***	-1.02***	-0.74***	-1.26***	-0.94***	-1.12***	-0.63***	-0.90***	-1.07***	-0.69***	-1.22***	-0.89***	-0.83***
	(0.04)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.08)	(0.03)	(0.05)	(0.07)	(0.05)	(0.04)	(0.03)
common land border	0.93***	0.70***	0.36***	0.20**	0.35***	0.52***	0.78***	0.57***	1.11***	0.08	0.25**	-0.33**	0.42***
	(0.08)	(0.08)	(0.13)	(0.10)	(0.08)	(0.07)	(0.15)	(0.08)	(0.12)	(0.18)	(0.11)	(0.16)	(0.08)
common language	0.45***	0.41***	0.39***	0.24	-0.04	0.19**	0.03	0.24**	0.05	0.58***	0.29**	0.23	0.45***
	(0.13)	(0.11)	(0.12)	(0.16)	(0.11)	(0.09)	(0.18)	(0.10)	(0.14)	(0.14)	(0.13)	(0.18)	(0.13)
common colonial ties	2.19***	-0.18	0.47*	1.21***	1.03***	0.53*	0.96***	-0.03	0.82***	-0.11	-0.91**	-0.09	-0.17
	(0.49)	(0.50)	(0.26)	(0.36)	(0.25)	(0.29)	(0.36)	(0.20)	(0.24)	(0.38)	(0.41)	(0.26)	(0.24)
ln (1 + tariff/100)	-0.54	-2.59***	0.90	-6.18***	-6.29***	-0.48	3.04***	-4.21***	-2.60**	-1.46	0.60	-2.39***	-1.38**
	(0.50)	(0.43)	(1.00)	(0.85)	(0.69)	(0.69)	(0.87)	(0.78)	(1.06)	(1.75)	(0.60)	(0.50)	(0.54)
regulatory distances:													
SPS-and-TBT NTMs	0.93	0.33	-5.41***	0.65	-0.87**	-4.14***	-4.64***	2.12***	-6.36***	2.13***	-0.56	-4.60***	1.40***
	(0.78)	(0.67)	(0.60)	(0.59)	(0.39)	(0.43)	(0.80)	(0.56)	(0.66)	(0.65)	(0.37)	(1.51)	(0.43)
pre-shipment NTMs	-1.24*	-0.44	-0.30	0.20	-0.34	-1.68***	-2.49***	-0.19	-1.69***	2.36**	-1.86**	2.53***	1.00*
	(0.68)	(0.45)	(0.44)	(0.41)	(0.35)	(0.32)	(0.56)	(0.47)	(0.58)	(0.95)	(0.79)	(0.91)	(0.55)
quantity-control NTMs	-69.23***	-20.27***	-16.84***	-27.11***	-16.25***	-15.18***	0.36	-27.35***	-5.31	-23.13***	48.52***	41.65***	-30.73***
	(4.69)	(3.14)	(2.50)	(3.63)	(2.47)	(3.05)	(6.48)	(3.13)	(4.62)	(5.34)	(9.83)	(6.79)	(3.91)
Nb observations	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996
R^2	1.000	0.957	0.999	0.991	0.986	0.995	0.845	0.878	1.000	0.882	1.000	0.918	0.959
share non-missing obs	0.81	0.81	0.88	0.91	0.93	0.93	0.91	0.96	0.85	0.81	0.84	0.83	0.96
share missing obs	0.19	0.19	0.12	0.09	0.07	0.07	0.09	0.04	0.15	0.19	0.16	0.17	0.04

Notes: Estimations based on the full trade matrix between the 57 countries over 2012-2015. All estimations include time-varying importer and exporter fixed effects. Domestic trade flows included in estimations. ***, ** and * indicate statistically significance at the 1%, 5%, and respectively 10%.

Table A4: Gravity estimates by groups of products with the value of σ used in simulations and statistically significant variables only

	Meat & meat products	Dairy	Fish & sea products	Vegetables	Fruit	Cereals & cereal products	Oilseeds & vegetable oils	Coffee, spices, cocoa, sugar	Non-alcoholic beverages	Wines	Other alcoholic beverages	Tobacco	Other products
ln geographic distance	-0.79***	-1.02***	-0.65***	-1.21***	-0.94***	-1.13***	-0.49***	-0.91***	-1.08***	-0.70***	-1.05***	-0.88***	-0.83***
	(0.05)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.08)	(0.03)	(0.05)	(0.08)	(0.10)	(0.04)	(0.03)
common land border	0.85***	0.71***	0.38***	0.33***	0.354***	0.52***	0.72***	0.56***	1.14***		0.53***	-0.26*	0.42***
	(0.07)	(0.08)	(0.14)	(0.09)	(0.08)	(0.07)	(0.15)	(0.08)	(0.11)		(0.14)	(0.14)	(0.08)
common language	0.44***	0.40***	0.29**			0.20**		0.23**		0.53***			0.44***
	(0.12)	(0.11)	(0.12)			(0.09)		(0.10)		(0.15)			(0.13)
common colonial ties	2.33***		0.47*	1.21***	1.01***	0.53*	1.76***		0.85***				
	(0.46)		(0.27)	(0.34)	(0.24)	(0.29)	(0.50)		(0.23)				
ln (1 + tariff/100)	-4.00	-2.59***	-2.00	-6.18***	-6.29***	-3.00	-2.00	-4.21***	-2.60**	-1.50	-6.00	-2.39***	-1.38**
		(0.43)		(0.85)	(0.69)			(0.78)	(1.06)			(0.50)	(0.54)
regulatory distances:													
SPS-and-TBT NTMs	2.05***		-5.36***		-0.90**	-4.25***	-3.67***	2.06***	-6.29***	4.68***	-1.35*	-4.44***	1.42***
	(0.80)		(0.39)		(0.37)	(0.40)	(0.69)	(0.42)	(0.49)	(0.74)	(0.72)	(1.38)	(0.43)
pre-shipment NTMs	-1.57**					-1.66***	-3.10***		-1.89***	2.21*	-2.81**	2.49***	0.99*
	(0.73)					(0.31)	(0.64)		(0.64)	(1.13)	(1.38)	(0.91)	(0.55)
quantity-control NTMs	-65.33***	-20.50***	-17.13***	-25.10***	-17.11***	-15.53***	15.27*	-27.63***		-19.77***	77.69***	41.10***	-30.70***
	(4.15)	(2.58)	(2.26)	(3.38)	(2.54)	(3.06)	(9.21)	(2.90)		(7.24)	(15.71)	(6.48)	(3.87)
Nb observations	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996	12,996
R^2	1.000	0.957	0.999	0.991	0.986	0.995	0.845	0.878	1.000	0.882	1.000	0.918	0.959
share non-missing obs	0.81	0.81	0.88	0.91	0.93	0.93	0.91	0.96	0.85	0.81	0.84	0.83	0.96
share missing obs	0.19	0.19	0.12	0.09	0.07	0.07	0.09	0.04	0.15	0.19	0.16	0.17	0.04

Notes: Estimations based on the full trade matrix between the 57 countries over 2012-2015. All estimations include time-varying importer and exporter fixed effects. Domestic trade flows included in estimations. ***, ** and * indicate statistically significance at the 1%, 5%, and respectively 10%.

Table A5: The effects of different Brexit scenarios by groups of products

Meat & meat products – effects on the UK and EU countries (σ=5)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-5.68	-17.02	-4.14	-16.52	-11.57	-12.95	-48.95	-8.24	-42.76	-15.28
Netherlands	-0.64	-7.57	-1.44	-10.58	-3.23	-0.57	-6.59	-1.12	-9.63	-2.48
Ireland	-3.14	-16.50	-4.88	-20.60	-11.39	-1.44	-9.36	-2.59	-13.45	-6.57
France	-0.26	-6.03	-0.90	-8.89	-2.08	-0.34	-5.68	-0.82	-8.53	-1.83
Germany	-0.20	-5.99	-0.82	-8.86	-1.89	-0.29	-5.64	-0.75	-8.50	-1.66
Spain	-0.37	-6.19	-1.00	-8.92	-2.22	-0.33	-5.37	-0.75	-8.07	-1.72
Belgium-Lux.	-0.16	-6.06	-0.80	-9.01	-1.94	-0.25	-5.81	-0.71	-8.80	-1.67
Italy	-0.19	-5.64	-0.77	-8.39	-1.72	-0.41	-5.58	-0.85	-8.27	-1.73
EU	-0.31	-6.20	-0.94	-9.04	-2.16	-0.36	-5.66	-0.82	-8.47	-1.83
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	-17.01	-56.44	-19.71	-56.87	-28.19	-8.66	-36.40	-13.85	-45.70	-34.65
Ireland	-14.62	-52.44	-17.36	-53.65	-27.30	-5.66	-27.17	-9.57	-35.94	-25.97
France	-16.83	-55.92	-19.35	-56.22	-27.27	-8.82	-36.94	-14.14	-46.25	-35.47
Germany	-17.06	-56.41	-19.68	-56.76	-27.85	-8.93	-37.17	-14.24	-46.48	-35.55
Spain	-16.78	-55.62	-19.10	-55.78	-26.55	-8.90	-37.25	-14.43	-46.67	-36.08
Belgium-Lux.	-17.16	-56.74	-19.91	-57.18	-28.46	-8.89	-36.97	-14.11	-46.23	-35.03
Italy	-16.80	-55.71	-19.19	-55.89	-26.69	-9.03	-37.56	-14.50	-46.93	-36.30
EU	-16.47	-55.34	-19.01	-55.79	-27.29	-7.93	-34.15	-12.86	-43.32	-32.73
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	4.21	24.49	1.62	18.53	-6.23	2.51	-2.99	3.03	-0.61	15.31
Netherlands	-0.19	-2.96	-1.13	-4.71	-3.65	0.57	3.60	2.02	5.47	6.43
Ireland	0.72	0.06	-0.11	-1.96	-2.59	1.59	8.10	3.58	11.08	10.66
France	-0.15	-2.72	-1.04	-4.41	-3.42	0.51	3.32	1.92	5.13	6.02
Germany	-0.23	-3.02	-1.15	-4.74	-3.62	0.48	3.20	1.88	4.99	5.97
Spain	-0.14	-2.58	-0.98	-4.22	-3.23	0.49	3.16	1.81	4.87	5.70
Belgium-Lux.	-0.25	-3.18	-1.21	-4.94	-3.77	0.49	3.31	1.93	5.14	6.24
Italy	-0.16	-2.66	-1.02	-4.31	-3.30	0.44	3.00	1.78	4.71	5.59
EU	-0.16	-2.73	-1.05	-4.42	-3.42	0.50	3.28	1.88	5.06	5.94
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-1.97	2.48	-2.36	0.50	-10.77	-5.92	-17.66	-3.92	-15.19	-4.84
Netherlands	-0.45	-2.78	-1.59	-4.17	-4.86	-0.26	0.18	-0.47	0.57	-1.26
Ireland	-1.25	-6.03	-2.78	-8.06	-7.78	-1.96	-6.09	-2.67	-6.22	-5.33
France	-0.41	-2.58	-1.51	-3.92	-4.56	-0.26	0.14	-0.47	0.52	-1.19
Germany	-0.38	-2.49	-1.48	-3.82	-4.53	-0.16	0.55	-0.33	0.97	-0.95
Spain	-0.39	-2.46	-1.42	-3.73	-4.34	-0.25	0.13	-0.44	0.51	-1.14
Belgium-Lux.	-0.39	-2.57	-1.52	-3.93	-4.73	-0.14	0.63	-0.31	1.07	-0.99
Italy	-0.35	-2.34	-1.40	-3.61	-4.25	-0.20	0.33	-0.39	0.73	-0.98
EU	-0.40	-2.55	-1.48	-3.87	-4.51	-0.24	0.20	-0.44	0.59	-1.13

Meat & meat products – effects on non-EU countries (σ=5)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.26	0.59	2.04	2.71	3.66	0.13	0.54	1.36	2.10	2.13
Australia	0.18	0.06	1.19	0.93	2.85	0.06	-0.18	0.56	-0.15	1.40
New Zealand	0.20	0.11	1.10	0.60	3.64	0.03	-0.13	0.30	-0.11	0.78
Chile	0.13	-0.18	0.73	-0.12	2.44	0.06	-0.24	0.53	-0.31	1.47
Israel	0.15	-0.47	0.69	-0.68	1.78	0.12	0.11	0.75	0.42	0.18
Switzerland	0.08	-2.79	-0.43	-4.46	0.62	0.45	0.96	6.31	6.44	4.90
China	0.12	-0.59	0.22	-1.49	1.73	0.07	-0.25	-0.45	-2.11	0.47
Brazil	0.27	0.63	0.26	-0.41	3.89	0.07	-0.25	0.28	-0.90	1.54
Thailand	0.16	-0.31	0.28	-1.42	1.73	0.04	-0.46	0.16	-1.39	0.81
India	0.39	0.53	0.14	-1.98	2.49	0.13	0.07	-0.18	-2.07	0.94
Canada	0.18	0.22	0.75	0.18	2.96	0.08	0.25	0.27	0.14	1.60
Argentina	0.12	-0.32	0.61	-0.45	2.55	0.04	-0.18	0.30	-0.46	1.15
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	8.42	-9.09	51.37	34.39	61.07	15.42	145.26	159.68	390.27	201.93
Australia	8.35	-9.52	31.93	16.67	60.51	15.56	147.08	146.04	369.01	234.51
New Zealand	8.39	-9.39	16.68	3.19	61.89	15.55	147.52	121.03	323.85	268.63
Chile	8.36	-9.67	15.90	1.75	60.56	15.56	147.13	114.90	310.24	244.31
Israel	8.21	-10.36	77.20	53.58	56.48	15.69	149.35	121.63	336.02	118.18
Switzerland	7.31	-16.39	385.34	296.13	41.37	16.25	156.94	140.24	370.62	200.72
China	8.18	-10.61	4.96	-9.05	56.62	15.70	149.30	-38.81	20.17	81.53
Brazil	8.43	-9.24	3.87	-8.87	61.98	15.53	146.50	27.77	142.83	231.47
Thailand	8.23	-10.35	109.37	81.44	56.85	15.67	148.72	-31.51	33.95	101.75
India	7.94	-11.28	100.74	70.70	50.53	15.36	142.15	-45.35	3.80	53.49
Canada	8.49	-8.77	-4.83	-15.67	62.40	15.43	145.71	15.14	121.67	197.90
Argentina	8.41	-9.43	14.25	0.43	62.22	15.54	147.61	65.83	212.98	291.31
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.03	-0.03	0.15	-0.03	0.44	-0.05	-0.25	-0.47	-0.90	-0.38
Australia	0.02	-0.10	0.19	-0.04	0.42	-0.01	-0.01	-0.13	-0.23	-0.08
New Zealand	0.03	-0.05	0.21	0.03	0.58	-0.01	0.04	-0.09	0.05	-0.32
Chile	0.02	-0.14	0.02	-0.39	0.43	-0.01	-0.01	-0.02	-0.05	-0.06
Israel	-0.01	-0.28	-0.11	-0.63	-0.12	0.03	0.27	0.28	0.71	0.46
Switzerland	-0.19	-1.83	-2.12	-4.14	-2.19	0.18	1.20	1.75	2.50	2.71
China	-0.02	-0.35	-0.05	-0.69	-0.07	0.03	0.26	0.41	0.90	0.57
Brazil	0.04	-0.03	-0.01	-0.39	0.63	-0.02	-0.09	0.24	0.37	-0.14
Thailand	-0.01	-0.29	-0.20	-0.81	-0.04	0.02	0.19	0.44	0.90	0.53
India	-0.09	-0.71	-0.94	-2.07	-1.01	-0.07	-0.62	0.97	1.29	0.77
Canada	0.04	0.07	0.41	0.44	0.64	-0.05	-0.19	-0.03	0.04	-0.41
Argentina	0.03	-0.06	0.04	-0.29	0.65	-0.02	0.06	0.12	0.35	-0.24
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.04	0.20	0.38	0.73	0.30	0.01	0.22	0.22	0.76	-0.14
Australia	0.01	0.01	0.11	0.18	0.07	-0.01	0.11	-0.08	0.22	-0.35
New Zealand	0.01	-0.03	0.07	-0.04	0.26	-0.02	0.01	-0.14	-0.07	-0.32
Chile	0.01	0.01	0.02	0.04	0.05	-0.01	0.14	-0.01	0.44	-0.38
Israel	-0.02	-0.21	-0.23	-0.56	-0.37	-0.01	0.07	-0.12	0.06	-0.25
Switzerland	-0.14	-0.95	-1.38	-1.96	-2.11	0.05	0.90	0.76	2.27	0.07
China	-0.02	-0.21	-0.33	-0.72	-0.45	-0.01	0.14	-0.28	-0.03	-0.38
Brazil	0.01	0.07	-0.19	-0.30	0.11	-0.02	0.10	-0.18	0.09	-0.52
Thailand	-0.02	-0.15	-0.35	-0.71	-0.42	-0.01	0.14	-0.16	0.10	-0.38
India	0.05	0.50	-0.77	-1.02	-0.61	0.14	1.22	0.18	1.07	0.40
Canada	0.04	0.16	0.03	-0.03	0.33	0.00	0.08	-0.38	-0.47	-0.32
Argentina	0.01	-0.04	-0.10	-0.28	0.19	-0.02	0.01	-0.13	0.01	-0.46

Dairy – effects on the UK and EU countries (σ=3.6)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-1.79	-11.44	-0.79	-10.46	-8.35	-3.24	-31.58	-1.89	-29.45	-11.00
Netherlands	-0.04	-1.79	0.04	-1.85	0.06	-0.05	-1.16	0.10	-1.19	0.06
Ireland	-1.04	-9.39	-1.13	-9.77	-5.12	-0.27	-2.66	-0.24	-2.78	-1.27
France	0.01	-1.24	0.10	-1.27	0.34	-0.01	-0.85	0.13	-0.86	0.20
Germany	0.03	-1.14	0.13	-1.16	0.47	-0.01	-0.86	0.14	-0.87	0.21
Spain	0.04	-0.96	0.14	-0.97	0.53	-0.02	-0.74	0.13	-0.72	0.18
Belgium-Lux.	0.05	-1.08	0.15	-1.13	0.53	0.00	-0.92	0.15	-0.96	0.30
Italy	0.04	-0.93	0.15	-0.93	0.55	-0.03	-0.78	0.12	-0.74	0.15
EU	0.01	-1.27	0.10	-1.30	0.34	-0.02	-0.86	0.13	-0.85	0.17
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	-5.30	-41.17	-6.68	-41.63	-22.95	-2.15	-16.02	-2.15	-17.28	-12.50
Ireland	-4.89	-39.11	-6.07	-39.70	-22.03	-1.60	-12.67	-1.65	-13.70	-9.57
France	-5.25	-40.82	-6.62	-41.25	-22.71	-2.16	-16.18	-2.16	-17.45	-12.68
Germany	-5.30	-41.11	-6.68	-41.55	-22.89	-2.18	-16.27	-2.18	-17.55	-12.74
Spain	-5.24	-40.77	-6.62	-41.21	-22.66	-2.18	-16.39	-2.18	-17.68	-12.87
Belgium-Lux.	-5.31	-41.26	-6.71	-41.72	-23.00	-2.18	-16.20	-2.18	-17.46	-12.63
Italy	-5.27	-40.86	-6.64	-41.28	-22.71	-2.20	-16.47	-2.20	-17.77	-12.96
EU	-5.19	-40.56	-6.53	-41.03	-22.63	-1.98	-15.04	-2.00	-16.23	-11.65
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	2.43	37.33	2.26	36.34	-0.05	1.09	-3.84	0.04	-4.17	10.47
Netherlands	0.07	-0.36	0.20	-0.40	0.05	0.01	0.76	-0.18	0.82	0.87
Ireland	0.31	1.56	0.53	1.49	1.00	0.31	2.88	0.09	3.13	2.65
France	0.08	-0.16	0.23	-0.18	0.14	0.00	0.65	-0.18	0.71	0.75
Germany	0.06	-0.37	0.20	-0.40	0.04	-0.01	0.60	-0.19	0.65	0.72
Spain	0.08	-0.17	0.22	-0.19	0.13	-0.01	0.52	-0.19	0.56	0.64
Belgium-Lux.	0.05	-0.46	0.19	-0.49	0.00	-0.01	0.65	-0.19	0.70	0.79
Italy	0.07	-0.24	0.21	-0.26	0.09	-0.02	0.47	-0.21	0.50	0.58
EU	0.07	-0.23	0.22	-0.25	0.10	0.00	0.62	-0.19	0.67	0.72
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-0.78	2.89	-0.03	3.14	-6.94	-3.13	-25.03	-2.24	-24.30	-6.89
Netherlands	-0.01	-0.54	0.13	-0.59	-0.62	-0.07	-0.18	-0.08	-0.18	-0.67
Ireland	-0.22	-2.03	-0.07	-2.20	-1.87	-0.53	-3.53	-0.59	-3.63	-2.84
France	0.00	-0.47	0.13	-0.51	-0.54	-0.08	-0.31	-0.10	-0.33	-0.68
Germany	0.01	-0.43	0.14	-0.46	-0.51	-0.05	-0.06	-0.06	-0.07	-0.55
Spain	0.01	-0.37	0.14	-0.40	-0.46	-0.07	-0.21	-0.08	-0.21	-0.59
Belgium-Lux.	0.01	-0.46	0.14	-0.50	-0.56	-0.05	-0.01	-0.05	-0.01	-0.57
Italy	0.02	-0.34	0.15	-0.36	-0.42	-0.05	-0.09	-0.06	-0.10	-0.51
EU	0.00	-0.45	0.14	-0.48	-0.52	-0.07	-0.22	-0.08	-0.23	-0.62

Dairy – effects on non-EU countries (σ=3.6)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.08	0.57	0.69	1.73	1.62	0.03	0.49	0.39	1.26	0.71
Australia	0.02	0.11	0.32	0.69	0.51	0.01	0.06	0.25	0.55	0.35
New Zealand	0.06	0.29	0.49	1.00	1.10	0.01	0.09	0.21	0.57	0.28
Chile	0.03	0.14	0.25	0.54	0.62	0.02	0.21	0.23	0.63	0.40
Israel	0.07	0.35	0.46	1.02	0.66	0.06	0.94	1.11	1.84	0.51
Switzerland	0.17	1.03	0.98	2.19	1.81	0.07	1.03	0.63	2.00	1.02
China	0.03	-0.14	0.25	0.17	0.52	0.03	0.20	-0.09	0.22	0.54
Brazil	0.04	0.13	0.12	0.28	0.68	0.02	0.37	0.11	0.43	0.53
Thailand	0.02	-0.10	0.23	0.28	0.51	0.01	-0.03	0.72	0.61	0.31
India	0.03	-0.03	0.23	0.24	0.61	0.01	0.02	0.21	0.28	0.31
Canada	0.03	0.24	0.12	0.72	0.83	0.02	0.40	0.81	1.12	0.55
Argentina	0.03	0.12	0.21	0.50	0.86	0.01	0.16	0.17	0.41	0.39
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	2.08	-6.82	34.21	24.51	21.28	5.57	134.65	79.44	291.61	153.57
Australia	2.08	-6.94	14.30	5.64	21.08	5.59	135.18	70.49	274.14	144.87
New Zealand	2.09	-6.88	4.01	-3.80	21.26	5.59	135.21	63.54	259.16	146.23
Chile	2.09	-6.96	6.90	-1.31	21.10	5.58	135.00	57.18	244.50	122.55
Israel	2.07	-7.14	61.01	49.07	19.85	5.56	134.39	26.78	175.82	19.08
Switzerland	2.20	-7.05	98.25	82.64	20.82	5.43	132.33	42.56	208.48	69.23
China	2.05	-7.44	-14.16	-21.28	20.31	5.61	135.76	-6.33	105.60	135.61
Brazil	2.08	-7.05	0.64	-7.25	20.85	5.57	134.75	-15.35	85.06	111.07
Thailand	2.06	-7.37	65.57	52.49	20.40	5.61	135.75	-8.37	101.95	130.90
India	2.04	-7.37	40.89	29.44	20.13	5.59	135.20	-21.47	72.56	97.50
Canada	2.09	-6.76	322.51	293.32	21.43	5.57	134.75	6.07	130.12	155.14
Argentina	2.10	-6.81	4.87	-3.11	21.44	5.58	135.22	21.03	168.07	206.12
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.05	0.01	0.15	0.15	-0.02	-0.18	-0.22	-0.46	-0.29
Australia	0.01	0.03	0.22	0.30	0.15	-0.01	-0.06	-0.36	-0.33	-0.04
New Zealand	0.01	0.06	0.26	0.37	0.20	-0.01	-0.06	-0.35	-0.29	-0.09
Chile	0.01	0.02	0.15	0.16	0.14	-0.02	-0.10	-0.29	-0.33	-0.11
Israel	0.00	-0.09	-0.22	-0.32	-0.16	-0.02	-0.23	0.06	-0.22	0.25
Switzerland	0.03	-0.19	-0.16	-0.40	0.02	-0.09	-0.71	-0.48	-1.16	-0.20
China	0.00	-0.14	0.28	0.11	-0.04	0.00	0.07	-0.32	-0.06	0.14
Brazil	0.01	-0.04	0.16	0.08	0.06	-0.02	-0.16	-0.14	-0.12	-0.12
Thailand	0.00	-0.11	-0.06	-0.17	-0.01	0.00	0.07	-0.09	0.07	0.15
India	-0.01	-0.14	-0.18	-0.31	-0.12	-0.01	-0.06	-0.25	-0.08	0.07
Canada	0.01	0.08	-1.05	-0.77	0.19	-0.02	-0.16	0.23	0.02	-0.29
Argentina	0.01	0.09	0.14	0.20	0.23	-0.01	-0.06	-0.19	-0.15	-0.16
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.01	0.13	0.16	0.33	0.21	0.01	0.08	0.15	0.18	0.06
Australia	0.01	0.05	0.26	0.24	0.03	0.00	0.01	0.03	-0.07	-0.12
New Zealand	0.01	0.04	0.26	0.21	0.06	0.00	-0.02	0.00	-0.16	-0.13
Chile	0.01	0.08	0.21	0.24	0.08	0.00	0.06	0.06	0.09	-0.06
Israel	0.02	0.16	-0.04	0.16	-0.18	0.02	0.26	0.18	0.48	-0.02
Switzerland	0.07	0.51	0.35	0.84	0.15	0.04	0.71	0.51	1.25	0.12
China	0.00	-0.05	0.23	0.05	-0.10	0.00	0.09	-0.05	-0.07	-0.06
Brazil	0.01	0.12	0.10	0.09	0.09	0.01	0.15	-0.06	0.01	0.03
Thailand	0.00	-0.05	0.06	-0.05	-0.11	0.00	0.06	0.12	0.12	-0.10
India	0.01	0.04	0.18	0.06	-0.05	0.01	0.18	0.36	0.37	0.07
Canada	0.01	0.12	-0.17	-0.01	0.21	0.01	0.03	0.89	0.76	0.02
Argentina	0.01	0.04	0.14	0.11	0.11	0.00	-0.05	0.00	-0.09	-0.12

Fish & sea products – effects on the UK and EU countries (σ=3)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-2.47	-6.62	-1.78	-6.05	-5.67	-2.06	-9.15	-1.66	-8.35	-4.20
Netherlands	-0.28	-1.54	-0.22	-1.47	-0.88	-0.22	-1.93	-0.17	-1.80	-0.25
Ireland	-0.71	-2.53	-0.54	-2.38	-2.14	-0.26	-3.08	-0.22	-2.84	-0.68
France	-0.16	-1.11	-0.12	-1.06	-0.49	-0.16	-1.62	-0.12	-1.51	-0.13
Germany	-0.14	-1.14	-0.10	-1.09	-0.41	-0.16	-1.57	-0.11	-1.46	-0.08
Spain	-0.16	-1.02	-0.13	-0.99	-0.55	-0.18	-1.59	-0.13	-1.48	-0.18
Belgium-Lux.	-0.14	-1.22	-0.09	-1.15	-0.41	-0.15	-1.62	-0.10	-1.50	-0.04
Italy	-0.10	-0.90	-0.08	-0.87	-0.34	-0.18	-1.53	-0.13	-1.43	-0.15
EU	-0.16	-1.12	-0.12	-1.07	-0.49	-0.16	-1.58	-0.12	-1.48	-0.11
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	-3.79	-13.83	-4.85	-14.54	-9.47	-5.29	-19.33	-4.03	-18.19	-15.49
Ireland	-3.80	-13.47	-4.65	-14.06	-9.58	-4.57	-17.94	-3.47	-16.82	-13.85
France	-3.73	-13.66	-4.85	-14.41	-9.24	-5.36	-19.39	-4.06	-18.25	-15.71
Germany	-3.78	-13.85	-4.89	-14.59	-9.39	-5.37	-19.44	-4.08	-18.29	-15.73
Spain	-3.72	-13.64	-4.90	-14.44	-9.16	-5.41	-19.47	-4.10	-18.32	-15.90
Belgium-Lux.	-3.78	-13.84	-4.85	-14.56	-9.48	-5.35	-19.43	-4.07	-18.29	-15.59
Italy	-3.72	-13.64	-4.88	-14.43	-9.14	-5.43	-19.50	-4.11	-18.35	-15.93
EU	-3.75	-13.73	-4.87	-14.49	-9.29	-5.29	-19.27	-4.01	-18.12	-15.57
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	1.30	5.77	1.72	6.27	-3.38	2.45	4.03	1.50	3.28	8.81
Netherlands	0.02	-0.18	0.05	-0.12	-0.15	0.36	0.24	0.27	0.22	1.94
Ireland	0.20	0.45	0.31	0.57	0.27	0.94	1.54	0.70	1.47	3.43
France	0.03	-0.10	0.05	-0.07	-0.09	0.31	0.18	0.24	0.17	1.74
Germany	0.00	-0.22	0.02	-0.19	-0.18	0.30	0.14	0.23	0.13	1.73
Spain	0.02	-0.12	0.01	-0.11	-0.10	0.27	0.11	0.22	0.10	1.57
Belgium-Lux.	0.00	-0.22	0.04	-0.17	-0.18	0.32	0.14	0.23	0.12	1.85
Italy	0.02	-0.12	0.02	-0.11	-0.10	0.26	0.08	0.20	0.07	1.54
EU	0.02	-0.15	0.03	-0.12	-0.12	0.31	0.17	0.24	0.16	1.72
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-1.60	-2.60	-0.99	-2.13	-5.47	-2.87	-7.91	-2.66	-7.90	-2.16
Netherlands	-0.24	-0.16	-0.18	-0.15	-1.28	-0.26	0.02	-0.23	-0.02	-1.13
Ireland	-0.62	-1.01	-0.47	-0.97	-2.22	-0.82	-1.46	-0.77	-1.53	-2.49
France	-0.21	-0.12	-0.16	-0.11	-1.15	-0.24	-0.02	-0.21	-0.04	-1.06
Germany	-0.20	-0.09	-0.15	-0.08	-1.14	-0.20	0.13	-0.17	0.10	-0.96
Spain	-0.18	-0.07	-0.14	-0.07	-1.04	-0.20	0.05	-0.16	0.04	-0.93
Belgium-Lux.	-0.21	-0.09	-0.16	-0.08	-1.22	-0.22	0.13	-0.20	0.09	-1.03
Italy	-0.17	-0.05	-0.14	-0.05	-1.02	-0.19	0.07	-0.15	0.06	-0.92
EU	-0.20	-0.12	-0.16	-0.11	-1.13	-0.22	0.03	-0.19	0.01	-1.01

Fish & sea products – effects on non-EU countries (σ=3)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.10	-0.13	0.40	0.14	0.76	0.00	0.34	0.85	1.31	0.19
Australia	0.06	-0.03	0.22	0.09	0.44	0.00	-0.05	0.14	0.16	0.22
New Zealand	0.07	0.02	0.26	0.18	0.52	0.00	-0.06	0.05	0.03	0.16
Chile	0.09	0.12	0.25	0.24	0.18	0.00	-0.24	0.04	-0.18	0.14
Israel	0.05	-0.13	0.12	-0.09	0.28	0.01	-0.03	0.38	0.40	0.21
Switzerland	0.03	-0.36	0.16	-0.28	0.20	0.01	-0.25	0.33	0.22	0.59
China	0.10	-0.03	-0.05	-0.15	0.59	-0.03	0.01	-0.03	-0.13	0.01
Brazil	0.06	-0.08	0.00	-0.16	0.38	0.00	-0.14	0.03	-0.11	0.30
Thailand	0.08	0.04	0.00	-0.06	0.45	-0.01	-0.05	-0.02	-0.17	0.11
India	0.08	0.09	0.18	0.14	0.55	0.01	-0.12	-0.02	-0.17	0.26
Canada	0.05	-0.05	0.02	-0.09	0.41	0.01	-0.08	0.01	-0.06	0.21
Argentina	0.10	0.02	-0.12	-0.19	0.52	-0.02	-0.17	-0.06	-0.28	0.17
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	3.30	5.36	11.37	13.98	12.07	0.96	8.97	22.94	32.67	14.03
Australia	3.32	5.49	7.22	9.85	12.03	0.95	8.77	21.39	30.74	15.77
New Zealand	3.34	5.56	4.40	7.03	12.13	0.95	8.78	16.08	25.01	12.03
Chile	3.34	5.69	6.34	9.15	11.52	0.97	8.54	6.84	14.77	-5.30
Israel	3.26	5.35	13.53	16.22	11.57	0.97	8.71	17.53	26.47	4.91
Switzerland	3.12	4.96	3.64	5.79	10.88	1.04	8.61	18.29	27.23	17.76
China	3.35	5.52	3.65	6.28	12.11	0.93	8.84	-4.35	2.94	9.19
Brazil	3.30	5.47	8.05	10.71	11.73	0.97	8.68	0.54	8.17	15.10
Thailand	3.35	5.58	28.44	31.75	12.09	0.94	8.76	-4.42	2.81	9.18
India	3.33	5.61	46.24	50.00	12.11	0.96	8.66	-0.03	7.46	14.24
Canada	3.29	5.43	-7.79	-5.55	11.91	0.96	8.78	1.40	9.19	14.19
Argentina	3.37	5.72	11.24	14.19	11.85	0.95	8.63	-7.69	-0.78	5.34
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	-0.02	0.01	0.01	0.05	-0.01	0.01	-0.05	-0.03	-0.05
Australia	0.01	0.00	-0.03	-0.02	0.06	-0.01	-0.14	-0.13	-0.26	0.01
New Zealand	0.02	0.03	0.03	0.06	0.10	-0.02	-0.13	-0.08	-0.22	0.03
Chile	0.03	0.04	-0.03	0.00	-0.02	0.00	-0.29	-0.02	-0.35	0.47
Israel	-0.01	-0.09	-0.14	-0.20	-0.06	0.00	-0.18	-0.06	-0.27	0.29
Switzerland	-0.07	-0.29	-0.12	-0.33	-0.27	0.05	-0.25	-0.15	-0.38	0.58
China	0.02	0.03	-0.08	-0.06	0.09	-0.03	-0.08	0.16	-0.05	0.01
Brazil	0.00	-0.03	-0.10	-0.13	-0.04	0.00	-0.19	0.07	-0.16	0.15
Thailand	0.02	0.04	-0.11	-0.08	0.10	-0.02	-0.14	0.17	-0.08	0.07
India	0.02	0.03	-0.16	-0.14	0.11	-0.01	-0.21	0.10	-0.17	0.07
Canada	0.00	-0.03	-0.01	-0.02	0.01	-0.01	-0.13	0.02	-0.13	0.03
Argentina	0.03	0.07	-0.10	-0.05	0.06	-0.02	-0.23	0.19	-0.11	0.27
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.01	0.00	0.03	0.02	0.04	0.00	0.02	0.03	0.02	-0.01
Australia	0.01	0.09	0.09	0.18	-0.01	0.00	0.09	0.11	0.19	-0.07
New Zealand	0.01	0.09	0.05	0.15	-0.02	-0.01	0.06	0.03	0.09	-0.12
Chile	0.00	0.20	0.01	0.23	-0.31	-0.03	0.16	0.05	0.23	-0.29
Israel	0.00	0.12	0.04	0.18	-0.19	0.01	0.21	0.18	0.38	-0.13
Switzerland	-0.04	0.17	0.10	0.26	-0.39	0.03	0.46	0.22	0.59	-0.11
China	0.02	0.06	-0.10	0.03	-0.01	0.00	0.03	-0.03	0.09	-0.10
Brazil	0.00	0.13	-0.05	0.11	-0.10	0.00	0.16	0.05	0.23	-0.06
Thailand	0.02	0.09	-0.11	0.05	-0.05	-0.01	0.05	-0.01	0.13	-0.15
India	0.01	0.14	-0.07	0.12	-0.05	-0.01	0.11	0.09	0.26	-0.16
Canada	0.00	0.09	-0.02	0.08	-0.02	0.00	0.12	-0.01	0.10	-0.02
Argentina	0.01	0.16	-0.13	0.08	-0.18	-0.02	0.08	-0.03	0.13	-0.23

Vegetables – effects on the UK and EU countries (σ=7.2)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-4.53	1.07	-3.28	-7.68	0.00	-49.01	2.85	-45.77	-18.80
Netherlands	0.00	-4.13	0.19	-3.88	-3.59	0.00	-1.93	0.22	-1.67	-3.38
Ireland	0.00	-3.66	0.26	-3.35	-3.50	0.00	-4.78	0.33	-4.28	-5.94
France	0.00	-2.13	0.11	-2.01	-2.44	0.00	-1.84	0.19	-1.61	-3.08
Germany	0.00	-1.81	0.09	-1.73	-2.29	0.00	-1.75	0.18	-1.53	-2.98
Spain	0.00	-3.58	0.30	-3.15	-3.04	0.00	-1.45	0.20	-1.20	-2.66
Belgium-Lux.	0.00	-2.33	0.12	-2.20	-2.66	0.00	-1.57	0.18	-1.37	-2.97
Italy	0.00	-1.93	0.08	-1.83	-2.21	0.00	-1.30	0.16	-1.12	-2.44
EU	0.00	-2.16	0.12	-2.03	-2.42	0.00	-1.63	0.18	-1.42	-2.83
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	0.00	-56.26	-3.82	-58.31	-29.35	0.00	-20.19	2.26	-17.23	-18.24
Ireland	0.00	-53.72	-3.60	-55.86	-27.44	0.00	-17.45	1.67	-15.04	-16.09
France	0.00	-55.33	-4.05	-57.56	-28.48	0.00	-20.74	2.37	-17.71	-18.44
Germany	0.00	-55.56	-3.98	-57.74	-28.68	0.00	-21.12	2.41	-18.04	-18.76
Spain	0.00	-55.24	-4.23	-57.58	-28.34	0.00	-21.62	2.50	-18.48	-19.00
Belgium-Lux.	0.00	-56.17	-3.83	-58.23	-29.27	0.00	-20.25	2.27	-17.28	-18.27
Italy	0.00	-55.14	-4.20	-57.45	-28.23	0.00	-21.91	2.57	-18.72	-19.20
EU	0.00	-55.35	-3.97	-57.54	-28.53	0.00	-20.84	2.37	-17.81	-18.57
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	9.92	0.35	10.50	-3.36	0.00	-2.59	-0.86	-3.55	5.98
Netherlands	0.00	-1.45	0.10	-1.38	-1.09	0.00	1.93	-0.12	1.84	1.14
Ireland	0.00	-0.46	0.12	-0.40	-0.60	0.00	2.58	-0.23	2.34	1.63
France	0.00	-1.13	0.06	-1.11	-0.90	0.00	1.80	-0.10	1.73	1.09
Germany	0.00	-1.23	0.08	-1.19	-0.96	0.00	1.71	-0.10	1.65	1.02
Spain	0.00	-1.13	0.04	-1.14	-0.89	0.00	1.59	-0.08	1.55	0.96
Belgium-Lux.	0.00	-1.42	0.10	-1.35	-1.08	0.00	1.92	-0.12	1.82	1.13
Italy	0.00	-1.10	0.04	-1.10	-0.87	0.00	1.52	-0.07	1.49	0.92
EU	0.00	-1.14	0.06	-1.12	-0.90	0.00	1.68	-0.09	1.62	1.01
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	2.28	0.75	3.17	-4.88	0.00	-6.95	0.40	-6.64	-1.58
Netherlands	0.00	-1.64	0.11	-1.55	-0.97	0.00	-0.19	0.01	-0.18	0.12
Ireland	0.00	-2.17	0.20	-1.97	-1.38	0.00	-1.72	0.08	-1.58	-0.79
France	0.00	-1.53	0.09	-1.46	-0.93	0.00	-0.40	0.03	-0.36	-0.03
Germany	0.00	-1.45	0.08	-1.40	-0.87	0.00	-0.22	0.01	-0.21	0.09
Spain	0.00	-1.35	0.07	-1.31	-0.82	0.00	-0.22	0.03	-0.17	0.07
Belgium-Lux.	0.00	-1.62	0.10	-1.54	-0.96	0.00	-0.21	0.01	-0.20	0.11
Italy	0.00	-1.29	0.06	-1.27	-0.78	0.00	-0.19	0.01	-0.17	0.09
EU	0.00	-1.42	0.08	-1.37	-0.86	0.00	-0.28	0.02	-0.26	0.04

Vegetables – effects on non-EU countries (σ=7.2)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.51	0.65	1.69	0.65	0.00	0.72	1.20	2.89	1.10
Australia	0.00	0.37	0.34	0.99	0.12	0.00	0.30	0.32	0.88	-0.03
New Zealand	0.00	0.50	0.42	1.27	0.15	0.00	0.15	0.21	0.53	-0.10
Chile	0.00	0.32	0.17	0.64	-0.36	0.00	0.23	0.21	0.58	-0.48
Israel	0.00	2.31	1.16	4.23	-0.35	0.00	0.59	0.50	1.43	-0.75
Switzerland	0.00	-0.25	0.39	0.53	-0.94	0.00	3.46	3.80	9.04	1.72
China	0.00	0.70	-0.02	0.66	0.65	0.00	0.22	0.05	0.30	0.06
Brazil	0.00	0.14	-0.09	-0.03	-0.27	0.00	0.81	-0.06	0.70	0.39
Thailand	0.00	0.17	0.31	0.48	0.20	0.00	-0.01	0.12	0.13	-0.09
India	0.00	0.14	0.17	0.34	0.06	0.00	0.32	0.40	0.79	0.36
Canada	0.00	0.32	-0.09	0.13	0.01	0.00	0.24	-0.05	0.13	-0.13
Argentina	0.00	0.65	-0.25	0.22	0.54	0.00	0.08	0.03	0.11	-0.22
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	-12.90	12.50	-2.58	36.27	0.00	82.84	64.25	202.00	105.31
Australia	0.00	-13.48	2.76	-11.51	35.69	0.00	83.92	45.62	169.97	65.64
New Zealand	0.00	-13.15	1.45	-12.19	35.97	0.00	83.91	43.32	165.93	53.51
Chile	0.00	-13.27	2.23	-12.09	34.82	0.00	83.13	23.91	129.27	13.89
Israel	0.00	-13.22	74.93	51.01	33.18	0.00	83.97	20.39	123.58	10.68
Switzerland	0.00	-18.21	232.98	172.10	29.81	0.00	91.12	45.90	179.07	67.31
China	0.00	-13.74	21.30	3.74	35.78	0.00	85.01	-2.18	83.65	86.48
Brazil	0.00	-13.75	4.34	-10.98	34.59	0.00	83.73	-13.66	61.17	66.04
Thailand	0.00	-13.62	480.40	396.49	35.95	0.00	84.98	-0.73	86.43	89.31
India	0.00	-14.10	185.06	143.05	35.05	0.00	85.49	11.95	110.34	113.31
Canada	0.00	-12.95	-24.85	-34.88	36.47	0.00	82.53	-18.93	49.96	55.75
Argentina	0.00	-12.91	8.02	-7.11	35.82	0.00	83.63	-15.79	57.32	60.42
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.01	0.01	0.02	-0.04	0.00	-0.10	-0.16	-0.39	-0.18
Australia	0.00	-0.08	0.03	-0.02	-0.09	0.00	0.01	-0.09	-0.17	-0.02
New Zealand	0.00	-0.02	0.06	0.09	-0.05	0.00	0.01	-0.08	-0.14	0.02
Chile	0.00	-0.05	-0.04	-0.13	-0.17	0.00	-0.07	-0.05	-0.17	0.13
Israel	0.00	-0.03	0.05	0.07	-0.34	0.00	0.01	-0.07	-0.12	0.31
Switzerland	0.00	-0.88	-0.28	-1.09	-0.74	0.00	0.73	0.02	0.53	0.40
China	0.00	-0.11	-0.04	-0.17	-0.07	0.00	0.12	0.05	0.20	0.03
Brazil	0.00	-0.13	-0.05	-0.24	-0.22	0.00	-0.01	0.09	0.15	-0.01
Thailand	0.00	-0.09	-0.05	-0.17	-0.05	0.00	0.11	0.07	0.21	0.04
India	0.00	-0.17	-0.10	-0.28	-0.15	0.00	0.17	0.08	0.26	0.06
Canada	0.00	0.00	0.07	0.11	0.00	0.00	-0.14	0.04	-0.06	-0.09
Argentina	0.00	0.02	-0.07	-0.11	-0.06	0.00	-0.02	0.10	0.15	0.04
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.09	0.13	0.34	0.15	0.00	0.08	0.12	0.31	0.19
Australia	0.00	-0.01	0.08	0.15	0.02	0.00	0.07	0.05	0.17	0.10
New Zealand	0.00	-0.01	0.07	0.12	-0.02	0.00	0.01	0.00	0.03	0.03
Chile	0.00	0.06	0.04	0.15	-0.11	0.00	0.12	0.08	0.28	0.06
Israel	0.00	-0.01	0.06	0.11	-0.27	0.00	0.02	0.00	0.04	0.07
Switzerland	0.00	-0.62	-0.02	-0.45	-0.34	0.00	0.26	0.26	0.65	0.40
China	0.00	-0.10	-0.05	-0.17	-0.03	0.00	0.01	-0.01	0.00	0.04
Brazil	0.00	0.01	-0.08	-0.13	0.01	0.00	0.14	-0.03	0.11	0.23
Thailand	0.00	-0.10	-0.06	-0.18	-0.04	0.00	-0.01	-0.01	-0.02	0.01
India	0.00	-0.14	-0.07	-0.22	-0.06	0.00	0.03	0.03	0.06	0.10
Canada	0.00	0.12	-0.03	0.05	0.08	0.00	0.12	-0.11	-0.06	0.08
Argentina	0.00	0.02	-0.08	-0.13	-0.03	0.00	0.00	-0.01	-0.02	0.03

Fruit – effects on the UK and EU countries (σ=7.3)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-5.49	0.37	-4.96	-7.33	0.00	-28.55	1.08	-26.70	-13.21
Netherlands	0.00	-1.47	-0.08	-1.55	-2.09	0.00	-1.92	0.00	-1.91	-2.98
Ireland	0.00	-1.83	-0.06	-1.90	-2.33	0.00	-2.42	-0.01	-2.41	-3.79
France	0.00	-0.86	-0.08	-0.95	-1.66	0.00	-1.18	-0.02	-1.19	-2.40
Germany	0.00	-0.80	-0.08	-0.90	-1.62	0.00	-1.44	0.00	-1.43	-2.54
Spain	0.00	-2.20	-0.04	-2.25	-2.42	0.00	-1.10	-0.01	-1.09	-2.28
Belgium-Lux.	0.00	-1.06	-0.08	-1.15	-1.85	0.00	-1.41	-0.02	-1.42	-2.60
Italy	0.00	-0.96	-0.08	-1.04	-1.65	0.00	-0.94	-0.01	-0.94	-2.10
EU	0.00	-0.98	-0.08	-1.07	-1.70	0.00	-1.19	-0.01	-1.19	-2.35
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	0.00	-36.29	-2.25	-38.21	-22.42	0.00	-32.19	0.65	-31.50	-26.27
Ireland	0.00	-35.65	-2.18	-37.55	-21.98	0.00	-28.06	0.48	-27.46	-23.19
France	0.00	-36.11	-2.27	-38.05	-22.25	0.00	-31.95	0.63	-31.27	-26.07
Germany	0.00	-35.96	-2.29	-37.92	-22.13	0.00	-32.50	0.66	-31.80	-26.49
Spain	0.00	-36.09	-2.30	-38.05	-22.21	0.00	-32.24	0.63	-31.58	-26.29
Belgium-Lux.	0.00	-36.30	-2.25	-38.22	-22.44	0.00	-32.11	0.65	-31.42	-26.22
Italy	0.00	-35.79	-2.35	-37.80	-21.99	0.00	-32.66	0.66	-31.97	-26.58
EU	0.00	-36.02	-2.28	-37.97	-22.19	0.00	-32.28	0.64	-31.59	-26.31
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	4.76	-0.03	4.74	-4.42	0.00	3.55	-0.30	3.14	7.39
Netherlands	0.00	-0.54	-0.09	-0.66	-0.60	0.00	1.09	0.11	1.24	0.77
Ireland	0.00	-0.23	-0.08	-0.35	-0.41	0.00	2.19	0.08	2.31	1.53
France	0.00	-0.49	-0.10	-0.61	-0.56	0.00	1.15	0.10	1.30	0.82
Germany	0.00	-0.47	-0.10	-0.60	-0.55	0.00	1.00	0.11	1.15	0.71
Spain	0.00	-0.49	-0.10	-0.62	-0.56	0.00	1.07	0.10	1.22	0.76
Belgium-Lux.	0.00	-0.54	-0.09	-0.66	-0.60	0.00	1.11	0.11	1.26	0.78
Italy	0.00	-0.43	-0.11	-0.58	-0.52	0.00	0.96	0.11	1.11	0.69
EU	0.00	-0.45	-0.10	-0.58	-0.54	0.00	1.05	0.11	1.20	0.75
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-2.96	0.26	-2.63	-5.97	0.00	-7.37	0.29	-7.03	-1.62
Netherlands	0.00	-0.93	-0.09	-1.06	-0.66	0.00	-0.39	0.00	-0.40	-0.06
Ireland	0.00	-1.86	-0.07	-1.95	-1.30	0.00	-1.62	0.02	-1.61	-0.90
France	0.00	-0.98	-0.09	-1.11	-0.70	0.00	-0.50	0.01	-0.50	-0.14
Germany	0.00	-0.86	-0.09	-0.99	-0.61	0.00	-0.39	0.00	-0.39	-0.06
Spain	0.00	-0.92	-0.09	-1.04	-0.65	0.00	-0.43	0.01	-0.42	-0.09
Belgium-Lux.	0.00	-0.95	-0.09	-1.08	-0.67	0.00	-0.41	0.00	-0.41	-0.07
Italy	0.00	-0.82	-0.09	-0.95	-0.59	0.00	-0.39	0.01	-0.37	-0.07
EU	0.00	-0.90	-0.09	-1.02	-0.64	0.00	-0.45	0.01	-0.44	-0.11

Fruit – effects on non-EU countries (σ=7.3)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.74	1.01	2.09	0.63	0.00	0.16	1.09	1.59	0.27
Australia	0.00	0.41	0.37	0.92	0.00	0.00	0.12	0.35	0.60	-0.27
New Zealand	0.00	0.51	0.61	1.35	0.40	0.00	0.09	0.21	0.37	-0.26
Chile	0.00	0.70	0.38	1.22	-1.12	0.00	0.17	0.07	0.29	-0.90
Israel	0.00	0.79	0.43	1.38	-1.25	0.00	-0.02	0.24	0.31	-1.32
Switzerland	0.00	0.18	0.22	0.49	-0.71	0.00	0.57	1.07	1.98	-0.55
China	0.00	0.46	-0.09	0.36	-0.03	0.00	0.08	-0.03	0.07	-0.21
Brazil	0.00	0.62	0.04	0.69	0.44	0.00	0.14	0.03	0.21	-0.54
Thailand	0.00	0.41	0.07	0.51	0.03	0.00	0.07	0.03	0.13	-0.30
India	0.00	0.50	0.14	0.69	0.15	0.00	0.13	0.12	0.30	-0.27
Canada	0.00	0.37	0.05	0.47	-0.17	0.00	0.16	0.06	0.26	-0.29
Argentina	0.00	0.59	-0.15	0.41	0.50	0.00	0.10	-0.02	0.10	-0.55
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	21.23	10.23	33.00	46.80	0.00	29.85	42.85	85.45	48.50
Australia	0.00	21.08	12.72	35.80	46.74	0.00	30.05	50.61	95.84	54.67
New Zealand	0.00	21.22	4.07	25.64	47.29	0.00	29.96	47.47	91.69	58.40
Chile	0.00	21.55	6.88	29.19	45.32	0.00	29.84	11.11	44.45	-11.49
Israel	0.00	20.79	59.45	91.35	43.90	0.00	30.33	11.65	45.83	-13.72
Switzerland	0.00	17.76	49.06	74.29	42.76	0.00	31.84	36.16	79.22	33.06
China	0.00	21.06	38.95	67.05	46.61	0.00	30.05	-2.80	26.77	39.16
Brazil	0.00	21.44	9.21	31.71	46.94	0.00	29.87	2.54	33.45	42.08
Thailand	0.00	21.15	317.52	402.44	47.01	0.00	30.01	0.90	31.55	44.34
India	0.00	20.75	204.53	265.06	46.42	0.00	30.26	6.83	39.53	52.65
Canada	0.00	21.17	-35.93	-22.75	46.77	0.00	29.85	12.91	46.74	57.58
Argentina	0.00	21.65	16.97	41.33	47.08	0.00	29.79	-3.08	26.13	38.09
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.04	0.01	0.06	-0.07	0.00	-0.03	-0.10	-0.16	-0.07
Australia	0.00	0.03	-0.01	0.03	-0.08	0.00	0.00	-0.10	-0.14	-0.08
New Zealand	0.00	0.05	0.04	0.10	-0.01	0.00	-0.02	-0.08	-0.11	-0.07
Chile	0.00	0.09	-0.03	0.05	-0.19	0.00	-0.03	-0.01	-0.04	0.22
Israel	0.00	-0.01	-0.06	-0.08	-0.33	0.00	0.04	0.05	0.10	0.32
Switzerland	0.00	-0.38	-0.14	-0.55	-0.49	0.00	0.25	-0.17	0.02	0.07
China	0.00	0.03	-0.07	-0.07	-0.08	0.00	0.00	0.10	0.12	0.01
Brazil	0.00	0.07	-0.07	-0.02	-0.06	0.00	-0.03	0.06	0.05	-0.14
Thailand	0.00	0.04	-0.08	-0.07	-0.04	0.00	-0.01	0.10	0.12	-0.01
India	0.00	-0.01	-0.10	-0.14	-0.10	0.00	0.03	0.09	0.14	-0.02
Canada	0.00	0.04	0.01	0.06	-0.08	0.00	-0.03	-0.02	-0.06	-0.10
Argentina	0.00	0.10	-0.07	0.02	-0.04	0.00	-0.04	0.09	0.07	-0.09
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.03	0.09	0.14	0.06	0.00	-0.02	0.08	0.08	0.12
Australia	0.00	0.00	0.09	0.12	0.07	0.00	-0.03	0.09	0.09	0.14
New Zealand	0.00	0.01	0.06	0.10	0.06	0.00	-0.03	0.03	0.00	0.08
Chile	0.00	0.03	0.01	0.04	-0.19	0.00	-0.06	0.04	-0.01	0.00
Israel	0.00	-0.03	-0.04	-0.09	-0.28	0.00	-0.03	0.02	0.00	0.05
Switzerland	0.00	-0.22	0.15	-0.02	-0.06	0.00	0.16	0.29	0.54	0.43
China	0.00	0.00	-0.08	-0.11	-0.01	0.00	-0.02	-0.01	-0.04	0.07
Brazil	0.00	0.02	-0.05	-0.04	0.12	0.00	-0.05	0.02	-0.02	0.18
Thailand	0.00	0.01	-0.08	-0.10	0.01	0.00	-0.03	0.00	-0.04	0.04
India	0.00	-0.02	-0.08	-0.12	0.02	0.00	-0.01	0.03	0.02	0.12
Canada	0.00	0.03	0.02	0.05	0.09	0.00	-0.01	0.00	-0.01	0.17
Argentina	0.00	0.03	-0.08	-0.06	0.08	0.00	-0.06	-0.01	-0.08	0.12

Cereals & cereal products – effects on the UK and EU countries (σ=4)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-12.04	2.47	-9.14	-9.31	0.00	-20.20	3.11	-16.35	-12.86
Netherlands	0.00	-1.05	-0.07	-1.17	-1.72	0.00	-1.23	-0.02	-1.28	-2.28
Ireland	0.00	-3.16	0.03	-3.24	-3.57	0.00	-3.91	-0.24	-4.12	-5.57
France	0.00	-1.12	-0.10	-1.27	-1.72	0.00	-0.78	-0.03	-0.84	-1.86
Germany	0.00	-0.77	-0.08	-0.89	-1.47	0.00	-0.69	-0.01	-0.73	-1.73
Spain	0.00	-0.56	-0.11	-0.71	-1.33	0.00	-0.70	-0.07	-0.79	-1.65
Belgium-Lux.	0.00	-0.85	-0.07	-0.97	-1.58	0.00	-0.86	0.00	-0.89	-1.97
Italy	0.00	-0.62	-0.12	-0.77	-1.35	0.00	-0.59	-0.03	-0.65	-1.51
EU	0.00	-0.80	-0.09	-0.93	-1.50	0.00	-0.76	-0.03	-0.82	-1.77
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	0.00	-27.87	-3.17	-30.43	-20.91	0.00	-16.89	0.18	-16.74	-14.36
Ireland	0.00	-24.36	-2.37	-26.55	-18.58	0.00	-14.33	-0.04	-14.34	-13.42
France	0.00	-27.79	-3.22	-30.37	-20.89	0.00	-16.90	0.25	-16.70	-14.26
Germany	0.00	-28.01	-3.25	-30.60	-21.02	0.00	-17.11	0.23	-16.93	-14.40
Spain	0.00	-27.72	-3.29	-30.34	-20.86	0.00	-17.31	0.35	-17.04	-14.41
Belgium-Lux.	0.00	-27.99	-3.20	-30.56	-20.99	0.00	-16.96	0.18	-16.80	-14.40
Italy	0.00	-27.99	-3.33	-30.62	-21.05	0.00	-17.35	0.31	-17.11	-14.41
EU	0.00	-27.30	-3.10	-29.83	-20.55	0.00	-16.91	0.23	-16.72	-14.30
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	7.72	-0.30	7.31	-3.52	0.00	3.01	-1.48	1.44	7.17
Netherlands	0.00	-0.10	0.04	-0.13	-0.20	0.00	1.00	-0.02	1.08	0.19
Ireland	0.00	1.84	0.29	2.01	0.89	0.00	2.38	-0.12	2.36	0.68
France	0.00	-0.07	0.03	-0.10	-0.18	0.00	1.00	0.01	1.10	0.25
Germany	0.00	-0.20	0.02	-0.24	-0.25	0.00	0.88	0.00	0.98	0.18
Spain	0.00	-0.09	0.02	-0.13	-0.19	0.00	0.77	0.05	0.91	0.17
Belgium-Lux.	0.00	-0.17	0.03	-0.21	-0.24	0.00	0.97	-0.02	1.05	0.17
Italy	0.00	-0.22	0.00	-0.28	-0.27	0.00	0.76	0.04	0.88	0.17
EU	0.00	-0.11	0.02	-0.15	-0.20	0.00	0.90	0.02	1.00	0.20
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-2.20	1.13	-1.06	-5.06	0.00	-9.20	1.43	-7.80	-1.60
Netherlands	0.00	-0.75	0.02	-0.80	-0.15	0.00	-0.64	-0.02	-0.67	0.06
Ireland	0.00	-1.75	0.09	-1.74	-0.51	0.00	-3.52	-0.20	-3.67	-1.39
France	0.00	-0.74	-0.01	-0.82	-0.18	0.00	-0.68	-0.04	-0.71	0.00
Germany	0.00	-0.66	0.00	-0.73	-0.13	0.00	-0.46	-0.02	-0.48	0.12
Spain	0.00	-0.58	-0.04	-0.68	-0.13	0.00	-0.49	-0.06	-0.55	0.06
Belgium-Lux.	0.00	-0.72	0.01	-0.78	-0.13	0.00	-0.55	-0.02	-0.57	0.11
Italy	0.00	-0.56	-0.03	-0.65	-0.13	0.00	-0.35	-0.03	-0.38	0.14
EU	0.00	-0.67	-0.01	-0.74	-0.15	0.00	-0.56	-0.03	-0.59	0.05

Cereals & cereal products – effects on non-EU countries (σ=4)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.37	0.16	0.57	0.12	0.00	0.05	0.03	0.09	-0.03
Australia	0.00	0.18	0.22	0.46	-0.12	0.00	-0.02	0.01	-0.01	-0.21
New Zealand	0.00	0.07	-0.04	0.03	-0.21	0.00	0.00	-0.07	-0.08	-0.21
Chile	0.00	0.10	-0.03	0.07	-0.22	0.00	0.02	-0.02	0.00	-0.29
Israel	0.00	0.01	-0.16	-0.17	-0.67	0.00	0.30	0.20	0.52	-0.50
Switzerland	0.00	0.95	1.32	2.53	-0.46	0.00	0.79	1.77	2.80	-0.04
China	0.00	0.04	-0.09	-0.06	-0.33	0.00	0.05	-0.06	-0.02	-0.14
Brazil	0.00	0.18	-0.04	0.14	-0.10	0.00	0.02	-0.03	-0.02	-0.17
Thailand	0.00	0.09	-0.04	0.03	-0.24	0.00	-0.03	-0.05	-0.09	-0.25
India	0.00	0.33	0.49	0.84	0.00	0.00	0.00	-0.05	-0.07	-0.32
Canada	0.00	0.13	0.06	0.21	-0.05	0.00	0.04	0.01	0.05	-0.13
Argentina	0.00	0.16	-0.16	-0.03	-0.11	0.00	0.01	-0.06	-0.05	-0.23
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	6.99	2.46	9.52	16.71	0.00	22.19	22.78	49.70	30.00
Australia	0.00	6.78	19.69	27.69	16.44	0.00	22.40	46.01	78.35	28.13
New Zealand	0.00	6.77	0.06	6.71	16.40	0.00	22.39	18.94	45.31	21.26
Chile	0.00	6.88	1.72	8.56	16.47	0.00	22.28	13.35	38.39	6.72
Israel	0.00	6.14	27.66	35.14	15.53	0.00	22.92	10.96	36.20	-14.12
Switzerland	0.00	6.02	66.61	76.50	15.40	0.00	22.83	45.81	78.57	7.57
China	0.00	6.59	23.01	30.89	16.18	0.00	22.55	-0.72	21.45	26.99
Brazil	0.00	6.90	4.62	11.60	16.55	0.00	22.28	8.41	32.27	25.15
Thailand	0.00	6.67	39.12	48.17	16.28	0.00	22.50	-2.58	19.13	24.57
India	0.00	6.68	79.39	91.01	16.39	0.00	22.45	1.42	23.98	29.42
Canada	0.00	6.96	1.40	8.13	16.69	0.00	22.19	16.28	42.22	27.78
Argentina	0.00	6.95	-4.75	1.66	16.59	0.00	22.28	-6.00	14.75	20.08
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.02	0.01	0.03	-0.04	0.00	-0.02	-0.01	-0.04	0.00
Australia	0.00	-0.03	-0.02	-0.04	-0.10	0.00	0.05	0.02	0.07	0.07
New Zealand	0.00	-0.03	-0.03	-0.06	-0.11	0.00	0.05	0.06	0.12	0.08
Chile	0.00	0.00	-0.06	-0.08	-0.10	0.00	0.01	0.07	0.10	0.05
Israel	0.00	-0.18	-0.20	-0.41	-0.32	0.00	0.24	0.29	0.57	0.25
Switzerland	0.00	-0.23	-0.15	-0.38	-0.38	0.00	0.21	-0.03	0.15	0.16
China	0.00	-0.07	-0.11	-0.19	-0.16	0.00	0.10	0.16	0.29	0.13
Brazil	0.00	0.00	-0.06	-0.07	-0.08	0.00	0.01	0.09	0.12	0.02
Thailand	0.00	-0.05	-0.11	-0.18	-0.14	0.00	0.09	0.16	0.27	0.11
India	0.00	-0.05	-0.20	-0.28	-0.13	0.00	0.07	0.15	0.25	0.01
Canada	0.00	0.01	0.02	0.04	-0.05	0.00	-0.02	0.02	-0.01	-0.01
Argentina	0.00	0.02	-0.08	-0.08	-0.07	0.00	0.01	0.12	0.16	0.03
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.02	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.04
Australia	0.00	-0.04	-0.02	-0.05	-0.05	0.00	-0.01	0.00	-0.02	0.05
New Zealand	0.00	-0.04	-0.05	-0.09	-0.06	0.00	-0.01	-0.02	-0.03	0.06
Chile	0.00	-0.01	-0.05	-0.07	-0.04	0.00	0.00	0.00	0.00	0.06
Israel	0.00	-0.18	-0.22	-0.43	-0.19	0.00	0.00	-0.02	-0.02	0.13
Switzerland	0.00	-0.15	0.02	-0.11	-0.12	0.00	0.07	0.18	0.27	0.26
China	0.00	-0.08	-0.12	-0.22	-0.10	0.00	-0.01	-0.01	-0.02	0.07
Brazil	0.00	-0.01	-0.07	-0.09	-0.02	0.00	-0.01	-0.01	-0.02	0.07
Thailand	0.00	-0.06	-0.12	-0.20	-0.08	0.00	-0.01	-0.01	-0.03	0.06
India	0.00	-0.05	-0.11	-0.19	-0.01	0.00	0.00	0.09	0.10	0.12
Canada	0.00	0.02	-0.01	0.01	0.01	0.00	0.00	-0.03	-0.03	0.06
Argentina	0.00	-0.01	-0.09	-0.12	-0.02	0.00	-0.02	-0.01	-0.04	0.05

Oilseeds & vegetable oils – effects on the UK and EU countries (σ=3)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-2.74	1.88	-1.15	-2.83	0.00	-4.36	1.99	-0.69	-3.56
Netherlands	0.00	-0.44	-0.25	-0.50	-0.47	0.00	-0.74	-0.18	-0.47	-0.80
Ireland	0.00	-0.68	-0.32	-1.04	-0.73	0.00	-1.22	-0.38	-0.69	-1.32
France	0.00	-0.38	-0.19	-0.36	-0.41	0.00	-0.59	-0.12	-0.27	-0.65
Germany	0.00	-0.37	-0.19	-0.32	-0.41	0.00	-0.57	-0.11	-0.27	-0.63
Spain	0.00	-0.36	-0.21	-0.42	-0.39	0.00	-0.61	-0.14	-0.31	-0.67
Belgium-Lux.	0.00	-0.40	-0.19	-0.34	-0.44	0.00	-0.59	-0.11	-0.27	-0.65
Italy	0.00	-0.34	-0.18	-0.35	-0.38	0.00	-0.58	-0.13	-0.29	-0.64
EU	0.00	-0.37	-0.19	-0.37	-0.41	0.00	-0.60	-0.13	-0.29	-0.66
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	0.00	-6.73	-3.40	-8.77	-5.96	0.00	-10.15	-5.02	-14.92	-10.52
Ireland	0.00	-6.80	-3.37	-9.01	-6.06	0.00	-9.65	-4.73	-13.80	-10.03
France	0.00	-6.72	-3.39	-8.73	-5.94	0.00	-10.14	-5.03	-14.94	-10.52
Germany	0.00	-6.73	-3.40	-8.74	-5.95	0.00	-10.18	-5.04	-15.00	-10.55
Spain	0.00	-6.69	-3.35	-8.66	-5.91	0.00	-10.13	-5.04	-14.95	-10.50
Belgium-Lux.	0.00	-6.75	-3.42	-8.80	-5.97	0.00	-10.17	-5.02	-14.95	-10.54
Italy	0.00	-6.69	-3.35	-8.66	-5.91	0.00	-10.14	-5.05	-15.00	-10.52
EU	0.00	-6.72	-3.38	-8.74	-5.95	0.00	-10.14	-5.04	-14.96	-10.52
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	2.42	-3.49	-1.21	-4.25	0.00	3.36	-2.32	1.89	4.05
Netherlands	0.00	-0.17	-0.08	-0.14	-0.20	0.00	0.15	0.27	0.71	0.16
Ireland	0.00	-0.07	0.02	0.07	-0.12	0.00	0.57	0.51	1.72	0.57
France	0.00	-0.16	-0.07	-0.12	-0.19	0.00	0.15	0.26	0.69	0.17
Germany	0.00	-0.18	-0.08	-0.15	-0.20	0.00	0.12	0.25	0.64	0.14
Spain	0.00	-0.14	-0.06	-0.09	-0.17	0.00	0.17	0.25	0.67	0.18
Belgium-Lux.	0.00	-0.19	-0.09	-0.16	-0.22	0.00	0.13	0.27	0.68	0.14
Italy	0.00	-0.15	-0.06	-0.10	-0.17	0.00	0.15	0.24	0.64	0.16
EU	0.00	-0.16	-0.07	-0.11	-0.19	0.00	0.16	0.26	0.68	0.17
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-2.18	1.58	-1.24	-2.62	0.00	-4.49	5.32	0.03	1.71
Netherlands	0.00	-0.10	-0.18	-0.47	-0.11	0.00	0.07	-0.11	-0.34	0.10
Ireland	0.00	-0.38	-0.34	-1.13	-0.38	0.00	-0.31	-0.36	-1.19	-0.26
France	0.00	-0.10	-0.17	-0.46	-0.11	0.00	0.06	-0.10	-0.34	0.08
Germany	0.00	-0.08	-0.17	-0.42	-0.09	0.00	0.09	-0.09	-0.28	0.11
Spain	0.00	-0.11	-0.17	-0.45	-0.12	0.00	0.03	-0.11	-0.36	0.05
Belgium-Lux.	0.00	-0.09	-0.18	-0.45	-0.10	0.00	0.10	-0.09	-0.29	0.12
Italy	0.00	-0.10	-0.16	-0.42	-0.11	0.00	0.05	-0.10	-0.33	0.07
EU	0.00	-0.10	-0.17	-0.45	-0.11	0.00	0.06	-0.10	-0.34	0.08

Oilseeds & vegetable oils – effects on non-EU countries (σ=3)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	-0.08	-0.09	0.05	-0.10	0.00	-0.16	-0.04	-0.07	-0.19
Australia	0.00	-0.11	0.23	0.33	-0.12	0.00	-0.14	0.08	0.08	-0.15
New Zealand	0.00	-0.13	0.01	0.10	-0.09	0.00	-0.13	0.00	0.01	-0.07
Chile	0.00	-0.11	-0.04	0.05	-0.13	0.00	-0.15	-0.02	-0.01	-0.18
Israel	0.00	-0.12	0.03	0.10	-0.18	0.00	-0.16	0.00	0.01	-0.23
Switzerland	0.00	-0.15	0.60	0.68	-0.17	0.00	-0.25	1.05	1.00	-0.28
China	0.00	-0.15	-0.05	0.05	-0.17	0.00	-0.09	-0.11	-0.14	-0.12
Brazil	0.00	-0.07	0.10	0.21	-0.09	0.00	-0.18	-0.01	-0.01	-0.21
Thailand	0.00	-0.11	-0.05	0.02	-0.14	0.00	-0.12	-0.03	-0.03	-0.15
India	0.00	-0.14	-0.04	0.06	-0.16	0.00	-0.11	-0.02	-0.02	-0.13
Canada	0.00	-0.10	0.46	0.58	-0.09	0.00	-0.14	0.06	0.06	-0.15
Argentina	0.00	-0.10	-0.14	-0.04	-0.13	0.00	-0.16	-0.05	-0.05	-0.20
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	4.33	-0.83	4.99	5.23	0.00	2.68	1.61	3.51	3.19
Australia	0.00	4.29	28.32	35.83	5.20	0.00	2.71	34.13	36.64	5.28
New Zealand	0.00	4.28	-2.86	2.82	5.24	0.00	2.72	11.09	13.17	24.75
Chile	0.00	4.32	-0.04	5.82	5.21	0.00	2.69	1.88	3.80	3.71
Israel	0.00	4.27	20.83	27.81	5.13	0.00	2.70	11.68	13.86	-5.62
Switzerland	0.00	4.24	142.32	156.09	5.12	0.00	2.66	73.03	76.44	2.67
China	0.00	4.25	2.94	8.96	5.14	0.00	2.76	-6.18	-4.44	1.41
Brazil	0.00	4.35	16.53	23.34	5.24	0.00	2.67	7.08	9.16	2.40
Thailand	0.00	4.28	118.53	131.24	5.17	0.00	2.74	-6.36	-4.61	1.18
India	0.00	4.26	72.82	82.92	5.16	0.00	2.75	-4.61	-2.85	3.01
Canada	0.00	4.32	28.60	36.07	5.25	0.00	2.69	32.44	34.99	6.40
Argentina	0.00	4.34	10.23	16.68	5.22	0.00	2.68	-5.80	-4.02	1.55
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	-0.07	0.00	0.04	-0.08	0.00	0.05	0.02	0.02	0.06
Australia	0.00	-0.08	0.03	0.06	-0.09	0.00	0.07	-0.19	-0.18	0.07
New Zealand	0.00	-0.08	-0.01	0.02	-0.10	0.00	0.08	-0.02	-0.02	-0.01
Chile	0.00	-0.07	-0.04	-0.01	-0.09	0.00	0.05	0.03	0.04	0.06
Israel	0.00	-0.09	-0.02	-0.01	-0.11	0.00	0.06	-0.04	-0.02	0.12
Switzerland	0.00	-0.12	-0.19	-0.22	-0.14	0.00	0.03	-0.51	-0.43	0.04
China	0.00	-0.09	-0.02	0.01	-0.10	0.00	0.11	0.05	0.04	0.13
Brazil	0.00	-0.06	0.00	0.04	-0.08	0.00	0.03	-0.02	0.00	0.05
Thailand	0.00	-0.08	-0.05	-0.03	-0.09	0.00	0.09	0.07	0.07	0.11
India	0.00	-0.08	-0.06	-0.04	-0.10	0.00	0.10	0.05	0.04	0.11
Canada	0.00	-0.07	0.12	0.16	-0.08	0.00	0.05	-0.23	-0.24	0.05
Argentina	0.00	-0.07	-0.03	0.01	-0.08	0.00	0.05	0.09	0.11	0.07
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	-0.03	-0.01	-0.01	-0.04	0.00	0.04	-0.02	-0.05	0.04
Australia	0.00	-0.05	0.12	0.12	-0.05	0.00	0.03	0.09	0.06	0.04
New Zealand	0.00	-0.05	0.01	0.01	0.00	0.00	0.03	0.02	-0.01	0.10
Chile	0.00	-0.04	-0.02	-0.03	-0.04	0.00	0.03	0.02	-0.02	0.05
Israel	0.00	-0.04	0.03	0.02	-0.08	0.00	0.06	0.05	0.02	0.03
Switzerland	0.00	-0.02	0.34	0.29	-0.03	0.00	0.10	0.53	0.51	0.11
China	0.00	-0.07	-0.04	-0.03	-0.08	0.00	0.02	-0.02	-0.03	0.02
Brazil	0.00	-0.02	0.01	0.00	-0.03	0.00	0.04	0.02	-0.04	0.05
Thailand	0.00	-0.06	-0.05	-0.05	-0.07	0.00	0.02	0.00	-0.02	0.02
India	0.00	-0.07	-0.03	-0.03	-0.08	0.00	0.02	0.02	0.01	0.02
Canada	0.00	-0.04	0.15	0.16	-0.03	0.00	0.03	0.03	-0.01	0.05
Argentina	0.00	-0.03	-0.06	-0.07	-0.04	0.00	0.04	-0.03	-0.08	0.04

Coffee, spices, cocoa, sugar – effects on the UK and EU countries (σ=5.2)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-0.14	-10.09	1.25	-8.32	-6.83	-0.22	-17.66	1.56	-15.38	-7.69
Netherlands	-0.01	-1.25	0.16	-1.03	-1.76	-0.01	-1.00	0.20	-0.74	-1.94
Ireland	-0.04	-3.32	0.24	-3.04	-3.57	-0.03	-3.13	0.13	-2.90	-4.24
France	-0.01	-0.71	0.17	-0.50	-1.34	-0.01	-0.77	0.18	-0.53	-1.65
Germany	-0.01	-0.79	0.15	-0.59	-1.39	-0.01	-0.80	0.19	-0.56	-1.66
Spain	-0.01	-0.61	0.14	-0.43	-1.15	-0.01	-0.76	0.19	-0.51	-1.56
Belgium-Lux.	-0.01	-0.86	0.17	-0.64	-1.49	-0.01	-0.72	0.21	-0.46	-1.71
Italy	0.00	-0.49	0.15	-0.29	-1.10	-0.01	-0.61	0.18	-0.38	-1.40
EU	-0.01	-0.70	0.16	-0.50	-1.30	-0.01	-0.75	0.19	-0.50	-1.60
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	-0.40	-29.66	-3.02	-31.93	-20.88	-0.34	-29.08	0.71	-27.99	-24.17
Ireland	-0.35	-27.02	-2.49	-29.07	-19.27	-0.27	-24.44	0.55	-23.46	-20.78
France	-0.39	-29.08	-3.00	-31.36	-20.40	-0.34	-29.34	0.75	-28.23	-24.30
Germany	-0.39	-29.39	-3.03	-31.67	-20.63	-0.35	-29.57	0.74	-28.45	-24.48
Spain	-0.39	-28.76	-3.18	-31.19	-20.07	-0.35	-29.68	0.81	-28.51	-24.52
Belgium-Lux.	-0.40	-29.74	-3.02	-32.01	-20.94	-0.34	-29.25	0.70	-28.16	-24.30
Italy	-0.39	-28.91	-3.08	-31.24	-20.20	-0.35	-29.86	0.79	-28.71	-24.64
EU	-0.39	-29.00	-3.01	-31.29	-20.36	-0.34	-29.10	0.73	-28.00	-24.15
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.07	5.97	0.26	6.25	-5.50	0.07	3.64	-0.95	2.39	7.32
Netherlands	0.00	-0.32	0.15	-0.16	-0.41	0.01	1.10	-0.16	0.93	0.69
Ireland	0.01	0.92	0.28	1.18	0.32	0.03	3.02	-0.20	2.78	2.00
France	0.00	-0.15	0.16	0.03	-0.28	0.01	0.99	-0.14	0.84	0.64
Germany	0.00	-0.27	0.15	-0.10	-0.36	0.01	0.90	-0.15	0.74	0.56
Spain	0.00	-0.07	0.12	0.06	-0.20	0.01	0.85	-0.13	0.72	0.55
Belgium-Lux.	0.00	-0.36	0.15	-0.20	-0.44	0.01	1.03	-0.16	0.86	0.64
Italy	0.00	-0.13	0.14	0.03	-0.25	0.01	0.77	-0.13	0.63	0.50
EU	0.00	-0.16	0.15	0.00	-0.28	0.01	0.93	-0.14	0.78	0.59
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-0.05	-2.84	0.77	-1.89	-5.54	-0.12	-8.31	0.52	-7.65	-0.04
Netherlands	-0.01	-0.88	0.13	-0.75	-0.55	-0.01	-0.56	-0.03	-0.59	-0.14
Ireland	-0.03	-2.38	0.16	-2.19	-1.59	-0.04	-3.27	-0.11	-3.33	-1.90
France	-0.01	-0.79	0.12	-0.67	-0.51	-0.01	-0.65	-0.04	-0.70	-0.23
Germany	-0.01	-0.72	0.12	-0.59	-0.45	-0.01	-0.45	-0.03	-0.49	-0.09
Spain	-0.01	-0.68	0.10	-0.57	-0.44	-0.01	-0.61	-0.02	-0.63	-0.25
Belgium-Lux.	-0.01	-0.83	0.13	-0.69	-0.51	-0.01	-0.46	-0.03	-0.50	-0.07
Italy	-0.01	-0.62	0.11	-0.51	-0.40	-0.01	-0.49	-0.04	-0.53	-0.16
EU	-0.01	-0.74	0.11	-0.62	-0.48	-0.01	-0.58	-0.03	-0.62	-0.20

Coffee, spices, cocoa, sugar – effects on non-EU countries (σ=5.2)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.01	0.57	0.40	1.07	0.20	0.01	0.42	0.84	1.48	0.35
Australia	0.01	0.52	0.34	0.96	0.16	0.00	0.28	0.41	0.81	0.04
New Zealand	0.01	0.55	0.33	0.98	0.18	0.00	0.26	0.42	0.80	0.15
Chile	0.01	0.58	0.15	0.77	-0.13	0.00	0.29	0.26	0.63	-0.43
Israel	0.01	0.59	0.42	1.11	-0.25	0.01	0.79	0.87	1.85	0.07
Switzerland	0.01	0.46	0.51	1.10	-0.51	0.00	0.32	0.47	0.91	-0.81
China	0.01	0.64	0.06	0.72	0.31	0.00	0.32	0.17	0.54	0.12
Brazil	0.01	1.07	0.14	1.23	0.88	0.00	0.28	0.14	0.46	-0.21
Thailand	0.01	0.50	0.30	0.85	0.23	0.00	0.20	0.19	0.45	-0.04
India	0.01	0.75	1.33	2.23	0.50	0.00	0.27	0.55	0.91	-0.04
Canada	0.01	0.52	0.13	0.71	0.08	0.00	0.27	0.14	0.45	0.03
Argentina	0.01	0.62	0.03	0.66	0.22	0.00	0.22	0.16	0.43	-0.11
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.23	13.36	15.01	29.35	27.01	0.22	23.43	36.38	68.77	36.69
Australia	0.23	13.35	3.03	15.90	27.13	0.22	23.51	37.43	70.22	34.98
New Zealand	0.23	13.51	2.25	15.20	27.33	0.22	23.52	35.39	67.83	35.82
Chile	0.23	13.64	2.81	15.87	27.06	0.22	23.39	13.31	40.29	-6.32
Israel	0.22	12.39	2.88	14.78	25.51	0.23	24.09	23.54	53.49	10.71
Switzerland	0.20	10.58	12.89	23.93	23.86	0.23	24.32	23.84	54.06	10.28
China	0.23	13.28	7.46	20.70	27.11	0.22	23.66	-0.87	22.90	31.37
Brazil	0.23	13.75	9.98	24.01	27.61	0.22	23.42	-2.43	20.66	26.70
Thailand	0.23	13.57	177.88	212.76	27.44	0.22	23.61	-2.58	20.75	29.09
India	0.23	13.47	281.19	327.87	27.45	0.22	23.55	-0.39	23.44	31.47
Canada	0.23	13.24	14.19	28.30	26.95	0.22	23.47	3.79	28.45	36.42
Argentina	0.23	13.97	19.46	34.91	27.80	0.22	23.39	-1.21	22.15	30.53
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.07	0.02	0.10	-0.05	0.00	-0.14	-0.29	-0.49	-0.20
Australia	0.00	0.07	0.06	0.15	-0.02	0.00	-0.12	-0.26	-0.43	-0.17
New Zealand	0.00	0.11	0.09	0.22	0.03	0.00	-0.12	-0.20	-0.35	-0.11
Chile	0.00	0.13	0.03	0.16	0.01	0.00	-0.15	-0.16	-0.34	0.08
Israel	0.00	-0.10	0.10	0.02	-0.27	0.00	0.02	-0.24	-0.27	0.13
Switzerland	-0.01	-0.48	0.05	-0.41	-0.60	0.00	0.07	-0.43	-0.44	0.02
China	0.00	0.07	0.02	0.09	-0.02	0.00	-0.08	-0.01	-0.09	-0.11
Brazil	0.00	0.15	0.01	0.17	0.06	0.00	-0.14	-0.04	-0.18	-0.21
Thailand	0.00	0.13	-0.06	0.06	0.05	0.00	-0.10	0.01	-0.08	-0.09
India	0.00	0.10	-0.40	-0.34	0.04	0.00	-0.11	0.07	-0.03	-0.17
Canada	0.00	0.05	0.08	0.15	-0.06	0.00	-0.13	-0.08	-0.23	-0.16
Argentina	0.00	0.20	0.00	0.20	0.10	0.00	-0.15	-0.03	-0.18	-0.18
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.11	0.24	0.40	0.16	0.00	0.04	0.22	0.30	0.21
Australia	0.00	0.10	0.21	0.35	0.14	0.00	0.02	0.15	0.20	0.16
New Zealand	0.00	0.09	0.16	0.29	0.09	0.00	-0.02	0.07	0.07	0.07
Chile	0.00	0.12	0.13	0.27	-0.07	0.00	-0.01	0.10	0.11	-0.08
Israel	0.00	-0.02	0.19	0.22	-0.10	0.00	0.09	0.10	0.20	0.17
Switzerland	0.00	-0.06	0.35	0.36	-0.02	0.01	0.42	0.30	0.77	0.59
China	0.00	0.07	0.01	0.07	0.09	0.00	0.00	-0.01	-0.02	0.10
Brazil	0.00	0.11	0.03	0.15	0.17	0.00	-0.04	0.02	-0.02	0.11
Thailand	0.00	0.08	-0.01	0.06	0.07	0.00	-0.05	0.05	0.00	0.02
India	0.00	0.09	-0.05	0.03	0.14	0.00	-0.01	0.34	0.37	0.10
Canada	0.00	0.10	0.07	0.19	0.13	0.00	0.06	-0.01	0.03	0.19
Argentina	0.00	0.12	0.03	0.14	0.15	0.00	-0.08	0.02	-0.06	0.05

Non-alcoholic beverages – effects on the UK and EU countries (σ=3.6)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-7.30	0.98	-6.22	-6.62	0.00	-16.36	1.56	-14.54	-12.26
Netherlands	0.00	-0.49	-0.04	-0.54	-0.44	0.00	-0.53	0.03	-0.51	-0.93
Ireland	0.00	-2.95	0.00	-3.01	-2.69	0.00	-3.67	-0.12	-3.77	-5.32
France	0.00	-0.37	-0.02	-0.40	-0.23	0.00	-0.31	0.02	-0.29	-0.76
Germany	0.00	-0.09	-0.02	-0.12	-0.09	0.00	-0.18	0.03	-0.15	-0.51
Spain	0.00	-0.05	-0.03	-0.09	-0.22	0.00	-0.22	0.02	-0.20	-0.61
Belgium-Lux.	0.00	-0.22	-0.03	-0.26	-0.24	0.00	-0.38	0.04	-0.35	-0.77
Italy	0.00	-0.11	-0.02	-0.14	-0.11	0.00	-0.13	0.03	-0.11	-0.49
EU	0.00	-0.23	-0.02	-0.27	-0.24	0.00	-0.31	0.02	-0.29	-0.70
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	0.00	-28.89	-1.35	-29.91	-24.71	0.00	-9.43	0.03	-9.43	-7.87
Ireland	0.00	-23.05	-0.86	-23.87	-19.74	0.00	-7.56	-0.10	-7.65	-8.12
France	0.00	-28.73	-1.29	-29.69	-24.77	0.00	-9.49	0.02	-9.52	-7.76
Germany	0.00	-29.03	-1.35	-30.03	-24.96	0.00	-9.68	0.03	-9.69	-7.86
Spain	0.00	-28.72	-1.35	-29.73	-24.75	0.00	-9.77	0.05	-9.77	-7.81
Belgium-Lux.	0.00	-28.99	-1.36	-30.01	-24.79	0.00	-9.53	0.03	-9.53	-7.93
Italy	0.00	-28.98	-1.33	-29.96	-25.05	0.00	-9.73	0.03	-9.75	-7.70
EU	0.00	-26.37	-1.14	-27.30	-22.64	0.00	-9.34	0.01	-9.37	-7.83
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	6.66	-0.16	6.45	-1.42	0.00	2.68	-0.81	1.84	5.18
Netherlands	0.00	0.19	0.05	0.22	0.41	0.00	0.42	-0.07	0.38	-0.44
Ireland	0.00	3.59	0.22	3.75	2.87	0.00	1.52	-0.14	1.42	-0.59
France	0.00	0.26	0.07	0.32	0.40	0.00	0.39	-0.08	0.33	-0.38
Germany	0.00	0.07	0.05	0.11	0.28	0.00	0.27	-0.07	0.22	-0.44
Spain	0.00	0.22	0.05	0.26	0.40	0.00	0.22	-0.06	0.17	-0.40
Belgium-Lux.	0.00	0.12	0.04	0.14	0.36	0.00	0.36	-0.07	0.32	-0.47
Italy	0.00	0.09	0.05	0.13	0.26	0.00	0.24	-0.07	0.19	-0.34
EU	0.00	0.24	0.06	0.28	0.40	0.00	0.32	-0.07	0.27	-0.39
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-1.89	0.59	-1.30	-3.58	0.00	-8.02	0.76	-7.28	-2.19
Netherlands	0.00	-0.30	0.05	-0.27	0.32	0.00	-0.49	0.01	-0.48	-0.09
Ireland	0.00	-1.08	0.10	-1.01	0.43	0.00	-4.51	-0.12	-4.59	-2.38
France	0.00	-0.28	0.06	-0.24	0.27	0.00	-0.54	-0.01	-0.55	-0.13
Germany	0.00	-0.20	0.05	-0.16	0.32	0.00	-0.27	0.01	-0.27	0.03
Spain	0.00	-0.16	0.04	-0.13	0.29	0.00	-0.38	0.00	-0.38	-0.11
Belgium-Lux.	0.00	-0.26	0.05	-0.23	0.34	0.00	-0.38	0.01	-0.37	-0.02
Italy	0.00	-0.17	0.05	-0.13	0.25	0.00	-0.26	0.00	-0.27	-0.02
EU	0.00	-0.23	0.05	-0.19	0.28	0.00	-0.46	0.00	-0.47	-0.11

Non-alcoholic beverages – effects on non-EU countries (σ=3.6)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.21	0.05	0.28	-0.08	0.00	0.23	0.16	0.41	0.36
Australia	0.00	0.06	0.01	0.08	-0.08	0.00	0.10	0.35	0.48	0.16
New Zealand	0.00	0.19	0.01	0.21	-0.03	0.00	0.09	0.02	0.11	0.13
Chile	0.00	0.06	-0.02	0.03	-0.22	0.00	0.09	-0.01	0.08	0.03
Israel	0.00	0.18	-0.03	0.16	-0.37	0.00	0.49	0.37	0.91	-0.03
Switzerland	0.00	1.90	1.21	3.29	0.22	0.00	0.07	0.29	0.38	0.26
China	0.00	0.14	0.00	0.13	-0.09	0.00	0.12	0.17	0.30	0.16
Brazil	0.00	0.05	-0.03	0.01	-0.13	0.00	0.04	0.01	0.04	0.04
Thailand	0.00	0.17	0.54	0.73	0.06	0.00	0.00	0.02	0.02	0.05
India	0.00	0.14	-0.04	0.09	-0.19	0.00	0.06	0.04	0.10	0.08
Canada	0.00	0.04	-0.01	0.03	-0.07	0.00	0.03	0.03	0.06	0.04
Argentina	0.00	0.06	0.00	0.06	-0.17	0.00	0.02	0.03	0.05	-0.01
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	5.11	6.37	11.77	9.96	0.00	16.03	14.41	32.66	22.08
Australia	0.00	5.06	22.84	29.01	9.95	0.00	16.07	35.73	57.43	22.08
New Zealand	0.00	5.07	4.81	10.09	9.99	0.00	16.05	14.45	32.71	22.04
Chile	0.00	4.93	1.43	6.41	9.79	0.00	16.09	7.46	24.66	7.16
Israel	0.00	4.87	7.40	12.46	9.77	0.00	16.11	9.49	27.26	-7.09
Switzerland	0.00	6.46	49.98	59.73	10.77	0.00	14.88	12.26	28.78	1.28
China	0.00	5.01	21.87	27.91	9.96	0.00	16.04	-1.44	14.34	17.81
Brazil	0.00	5.05	6.79	12.15	9.90	0.00	16.06	-1.58	14.19	17.87
Thailand	0.00	5.19	72.75	81.52	10.12	-0.01	15.97	-1.54	14.16	17.80
India	0.00	4.90	30.53	36.81	9.87	-0.01	15.93	2.05	18.20	21.80
Canada	0.00	5.05	18.52	24.31	9.90	0.00	16.02	12.09	30.19	22.03
Argentina	0.00	4.95	14.68	20.20	9.83	0.00	16.11	-1.55	14.28	17.90
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00
Australia	0.00	-0.01	-0.07	-0.08	0.00	0.00	0.01	0.08	0.10	-0.01
New Zealand	0.00	-0.01	-0.01	-0.02	0.01	0.00	0.00	0.01	0.02	-0.02
Chile	0.00	-0.06	0.01	-0.05	-0.06	0.00	0.02	-0.01	0.02	0.00
Israel	0.00	-0.08	-0.04	-0.12	-0.06	0.00	0.03	0.03	0.07	0.01
Switzerland	0.00	0.34	0.16	0.53	0.23	0.00	-0.54	-0.28	-0.85	-0.21
China	0.00	-0.03	-0.11	-0.15	-0.01	0.00	0.00	0.09	0.10	-0.04
Brazil	0.00	-0.02	-0.02	-0.04	-0.02	0.00	0.01	0.02	0.03	-0.01
Thailand	0.00	0.02	-0.04	-0.02	0.05	0.00	-0.03	0.04	0.02	-0.04
India	0.00	-0.09	-0.29	-0.40	-0.07	-0.01	-0.05	0.04	0.00	-0.13
Canada	0.00	-0.02	-0.04	-0.06	-0.03	0.00	-0.01	0.00	-0.01	-0.03
Argentina	0.00	-0.05	-0.07	-0.12	-0.04	0.00	0.03	0.04	0.07	0.00
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00
Australia	0.00	-0.01	-0.06	-0.07	0.00	0.00	0.00	0.01	0.01	0.01
New Zealand	0.00	0.00	-0.01	-0.01	0.02	0.00	0.01	0.00	0.01	0.01
Chile	0.00	-0.02	0.00	-0.01	0.00	0.00	0.04	-0.01	0.04	0.05
Israel	0.00	-0.02	-0.03	-0.05	-0.01	0.00	0.06	0.01	0.07	0.05
Switzerland	0.00	0.39	0.20	0.62	0.15	0.00	0.05	0.04	0.09	-0.08
China	0.00	0.00	-0.07	-0.07	0.03	0.00	0.03	0.05	0.08	0.04
Brazil	0.00	-0.01	-0.01	-0.02	0.01	0.00	0.01	0.00	0.01	0.03
Thailand	0.00	0.02	-0.03	-0.01	0.03	0.00	0.00	0.01	0.01	-0.02
India	0.00	0.04	-0.03	0.00	0.09	0.00	0.13	0.26	0.40	0.16
Canada	0.00	0.01	0.00	0.01	0.02	0.00	0.03	0.04	0.07	0.05
Argentina	0.00	-0.02	-0.03	-0.05	0.00	0.00	0.02	0.05	0.07	0.04

Wines – effects on the UK and EU countries (σ=2.5)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-1.49	0.60	0.07	-1.18	0.00	-3.50	0.25	-3.47	-3.54
Netherlands	0.00	-0.12	0.33	0.85	0.13	0.00	0.01	0.23	0.60	-0.34
Ireland	0.00	-0.43	0.43	0.77	0.13	0.00	-0.02	0.23	0.45	-0.88
France	0.00	-0.35	0.30	0.63	-0.08	0.00	0.07	0.26	0.70	-0.16
Germany	0.00	-0.05	0.27	0.83	0.09	0.00	0.03	0.25	0.66	-0.17
Spain	0.00	-0.07	0.27	0.77	0.05	0.00	0.10	0.23	0.81	-0.04
Belgium-Lux.	0.00	-0.06	0.31	0.85	0.11	0.00	0.06	0.24	0.68	-0.20
Italy	0.00	-0.09	0.22	0.71	-0.04	0.00	0.10	0.25	0.78	0.02
EU	0.00	-0.10	0.27	0.78	0.04	0.00	0.07	0.25	0.72	-0.11
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	0.00	-11.27	-0.20	-11.38	-10.91	0.00	-2.73	1.02	-0.97	-2.68
Ireland	0.00	-11.04	-0.10	-11.00	-10.48	0.00	-2.28	0.85	-0.81	-2.72
France	0.00	-11.35	-0.27	-11.56	-11.08	0.00	-2.81	1.11	-0.92	-2.58
Germany	0.00	-11.27	-0.27	-11.49	-11.02	0.00	-2.86	1.11	-0.96	-2.61
Spain	0.00	-11.28	-0.26	-11.57	-11.11	0.00	-2.91	1.11	-0.86	-2.53
Belgium-Lux.	0.00	-11.38	-0.21	-11.50	-11.04	0.00	-2.79	1.06	-1.00	-2.67
Italy	0.00	-11.31	-0.32	-11.62	-11.15	0.00	-2.95	1.18	-0.90	-2.53
EU	0.00	-11.25	-0.25	-11.45	-10.98	0.00	-2.87	1.13	-0.91	-2.56
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	4.15	0.54	5.19	-0.93	0.00	2.18	-0.69	0.43	2.10
Netherlands	0.00	0.21	0.19	0.84	0.26	0.00	0.59	-0.24	-0.24	-0.07
Ireland	0.00	0.59	0.18	1.20	0.57	0.00	1.11	-0.43	-0.05	-0.11
France	0.00	0.11	0.18	0.73	0.18	0.00	0.49	-0.14	-0.18	0.04
Germany	0.00	0.15	0.18	0.76	0.21	0.00	0.44	-0.14	-0.22	0.02
Spain	0.00	0.12	0.18	0.74	0.19	0.00	0.38	-0.14	-0.11	0.10
Belgium-Lux.	0.00	0.10	0.19	0.73	0.17	0.00	0.52	-0.20	-0.27	-0.06
Italy	0.00	0.08	0.17	0.69	0.16	0.00	0.34	-0.07	-0.16	0.10
EU	0.00	0.14	0.18	0.76	0.21	0.00	0.43	-0.14	-0.18	0.05
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-1.29	0.42	-0.26	-1.24	0.00	-5.22	-0.12	-5.18	-0.31
Netherlands	0.00	-0.35	0.14	0.14	0.04	0.00	-0.56	-0.04	-0.69	-0.22
Ireland	0.00	-0.66	0.26	0.03	0.07	0.00	-1.24	0.08	-1.15	-0.50
France	0.00	-0.29	0.09	0.11	-0.02	0.00	-0.40	-0.10	-0.62	-0.20
Germany	0.00	-0.26	0.09	0.13	-0.01	0.00	-0.41	-0.09	-0.62	-0.22
Spain	0.00	-0.23	0.09	0.07	-0.06	0.00	-0.35	-0.10	-0.67	-0.25
Belgium-Lux.	0.00	-0.31	0.12	0.16	0.04	0.00	-0.41	-0.07	-0.57	-0.14
Italy	0.00	-0.20	0.04	0.10	-0.06	0.00	-0.28	-0.13	-0.59	-0.22
EU	0.00	-0.26	0.08	0.11	-0.03	0.00	-0.40	-0.09	-0.64	-0.24

Wines – effects on non-EU countries (σ=2.5)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.76	0.51	1.45	0.51	0.00	0.50	0.58	2.22	0.93
Australia	0.00	0.70	-0.87	0.45	0.57	0.00	0.36	-0.47	0.38	0.75
New Zealand	0.00	0.78	0.52	1.63	0.65	0.00	0.30	0.38	1.67	0.80
Chile	0.00	0.77	0.40	1.50	0.42	0.00	0.33	0.28	1.59	0.48
Israel	0.00	0.84	-0.46	0.78	0.66	0.00	0.43	-0.16	0.91	0.71
Switzerland	0.00	0.53	-0.58	0.53	0.46	0.00	0.37	-0.40	0.26	0.47
China	0.00	0.54	0.08	0.97	0.25	0.00	0.40	0.28	1.49	0.87
Brazil	0.00	0.64	0.25	1.26	0.52	0.00	0.35	0.24	1.53	0.71
Thailand	0.00	0.53	-0.01	0.97	0.32	0.00	0.30	0.28	1.27	0.71
India	0.00	0.67	0.14	1.11	0.51	0.00	0.36	0.28	1.52	0.74
Canada	0.00	0.70	-0.07	0.79	0.39	0.00	0.30	-0.19	1.16	0.79
Argentina	0.00	0.80	0.24	1.54	0.76	0.00	0.31	0.22	1.45	0.70
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	2.64	2.64	4.80	2.34	0.00	4.20	4.88	11.11	5.31
Australia	0.00	2.75	-18.89	-16.85	2.44	0.00	4.26	-15.66	-10.99	5.43
New Zealand	0.00	3.00	2.89	5.45	2.61	0.00	4.28	5.17	11.44	5.57
Chile	0.00	2.76	1.79	4.13	2.32	0.00	4.31	3.16	9.30	1.63
Israel	0.00	2.62	4.26	6.75	2.50	0.00	4.12	-5.20	-0.08	4.92
Switzerland	0.00	2.13	-1.95	0.20	2.29	0.00	4.48	-11.95	-7.29	4.93
China	0.00	2.44	7.32	9.55	2.12	0.00	4.46	1.32	7.32	5.63
Brazil	0.00	2.62	20.82	23.47	2.41	0.00	4.29	1.31	7.24	5.46
Thailand	0.00	2.53	68.47	72.17	2.20	0.00	4.46	1.40	7.32	5.64
India	0.00	2.64	224.46	231.33	2.38	0.00	4.24	1.55	7.42	5.65
Canada	0.00	2.65	-21.21	-19.56	2.29	0.00	4.22	-8.02	-2.41	5.46
Argentina	0.00	2.99	14.01	16.92	2.66	0.00	4.32	1.16	7.15	5.40
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.14	0.06	0.63	0.17	0.00	-0.77	-0.52	-0.89	-0.33
Australia	0.00	0.23	0.35	1.03	0.27	0.00	-0.70	1.46	0.67	-0.21
New Zealand	0.00	0.40	-0.02	0.80	0.46	0.00	-0.69	-0.21	-0.56	-0.03
Chile	0.00	0.26	0.16	0.86	0.28	0.00	-0.65	-0.28	-0.63	-0.02
Israel	0.00	0.09	-0.09	0.43	0.14	0.00	-0.85	0.76	-0.21	-0.64
Switzerland	0.00	-0.08	0.20	0.56	0.01	0.00	-0.47	1.30	0.25	-0.62
China	0.00	0.12	0.01	0.56	0.17	0.00	-0.50	0.11	-0.27	0.06
Brazil	0.00	0.16	-0.02	0.58	0.20	0.00	-0.67	-0.13	-0.58	-0.35
Thailand	0.00	0.17	-0.59	0.00	0.23	0.00	-0.49	0.20	-0.28	0.07
India	0.00	0.15	-3.46	-2.96	0.20	0.00	-0.72	-0.02	-0.56	-0.31
Canada	0.00	0.15	0.48	1.08	0.21	0.00	-0.74	0.45	0.23	-0.14
Argentina	0.00	0.42	0.14	0.99	0.43	0.00	-0.64	-0.08	-0.46	-0.19
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.46	0.32	0.54	0.20	0.00	0.33	0.25	-0.10	0.03
Australia	0.00	0.42	-0.87	-0.40	0.13	0.00	0.19	-1.21	-1.41	-0.14
New Zealand	0.00	0.41	0.13	0.34	0.02	0.00	0.01	0.15	-0.47	-0.43
Chile	0.00	0.39	0.17	0.38	0.01	0.00	0.13	0.01	-0.48	-0.26
Israel	0.00	0.51	-0.44	0.14	0.38	0.00	0.42	-0.35	-0.29	0.24
Switzerland	0.00	0.28	-0.77	-0.15	0.37	0.00	0.36	-0.97	-0.71	0.36
China	0.00	0.30	-0.07	0.17	-0.04	0.00	0.18	-0.07	-0.39	-0.21
Brazil	0.00	0.40	0.08	0.35	0.21	0.00	0.24	0.10	-0.23	0.01
Thailand	0.00	0.30	-0.12	0.17	-0.04	0.00	0.12	0.47	0.17	-0.27
India	0.00	0.43	0.01	0.34	0.19	0.00	0.28	3.59	3.40	-0.01
Canada	0.00	0.45	-0.26	-0.13	0.08	0.00	0.29	-0.73	-1.20	-0.12
Argentina	0.00	0.39	0.05	0.28	0.11	0.00	-0.03	-0.09	-0.71	-0.31

Other alcoholic beverages – effects on the UK and EU countries (σ=7)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-14.19	16.98	3.07	-6.27	0.00	-4.72	6.85	2.02	-2.39
Netherlands	0.00	-2.16	0.85	-1.36	-1.61	0.00	-1.04	0.25	-0.75	-0.71
Ireland	0.00	-4.86	1.52	-3.73	-3.85	0.00	-1.21	0.86	-0.50	-0.68
France	0.00	-1.97	0.70	-1.32	-1.57	0.00	-0.49	0.40	-0.10	-0.28
Germany	0.00	-0.13	1.43	1.18	0.08	0.00	-0.30	0.43	0.14	-0.13
Spain	0.00	-0.09	1.35	1.14	0.05	0.00	-0.38	0.22	-0.15	-0.25
Belgium-Lux.	0.00	-0.13	1.75	1.48	0.16	0.00	0.11	1.00	1.06	0.30
Italy	0.00	-0.05	1.20	1.04	0.09	0.00	-0.08	0.38	0.29	0.02
EU	0.00	-0.63	1.21	0.46	-0.39	0.00	-0.29	0.42	0.12	-0.12
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	0.00	-20.18	-11.46	-30.87	-17.86	0.00	-17.74	13.63	-4.20	-9.92
Ireland	0.00	-14.86	-5.79	-21.67	-12.89	0.00	-14.31	13.11	-1.09	-7.18
France	0.00	-19.85	-11.91	-30.97	-17.71	0.00	-17.18	15.28	-2.27	-9.15
Germany	0.00	-20.58	-12.47	-31.97	-18.34	0.00	-17.63	15.10	-2.91	-9.59
Spain	0.00	-20.60	-13.21	-32.57	-18.50	0.00	-17.07	16.70	-1.02	-8.80
Belgium-Lux.	0.00	-20.43	-11.68	-31.23	-18.09	0.00	-17.88	13.45	-4.50	-10.06
Italy	0.00	-20.99	-13.63	-33.19	-18.85	0.00	-17.26	16.87	-1.06	-9.00
EU	0.00	-19.97	-12.02	-31.10	-17.80	0.00	-16.81	14.59	-2.46	-8.99
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	0.65	2.03	2.95	-0.86	0.00	1.21	-3.50	-2.50	1.65
Netherlands	0.00	1.16	0.96	1.93	1.24	0.00	-0.55	-0.45	-0.85	-0.74
Ireland	0.00	2.37	2.00	4.17	2.32	0.00	0.24	-0.54	-0.23	-0.16
France	0.00	1.25	0.91	1.96	1.29	0.00	-0.42	-0.18	-0.47	-0.58
Germany	0.00	1.08	0.80	1.69	1.15	0.00	-0.53	-0.21	-0.59	-0.67
Spain	0.00	1.09	0.70	1.60	1.14	0.00	-0.40	0.06	-0.22	-0.51
Belgium-Lux.	0.00	1.10	0.91	1.83	1.18	0.00	-0.59	-0.49	-0.91	-0.77
Italy	0.00	1.00	0.62	1.44	1.06	0.00	-0.44	0.09	-0.23	-0.55
EU	0.00	1.13	0.79	1.73	1.19	0.00	-0.45	-0.08	-0.41	-0.59
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.00	-1.02	3.10	2.19	-1.39	0.00	-1.66	1.04	-0.74	-0.53
Netherlands	0.00	0.48	0.39	0.74	0.64	0.00	-0.67	-0.56	-1.17	-0.59
Ireland	0.00	-0.20	0.47	0.20	0.14	0.00	-2.51	-1.50	-3.81	-2.13
France	0.00	0.36	0.15	0.40	0.50	0.00	-0.87	-0.76	-1.53	-0.78
Germany	0.00	0.46	0.18	0.51	0.58	0.00	-0.62	-0.62	-1.16	-0.56
Spain	0.00	0.34	-0.05	0.19	0.44	0.00	-0.74	-0.75	-1.39	-0.70
Belgium-Lux.	0.00	0.51	0.42	0.79	0.67	0.00	-0.59	-0.49	-1.02	-0.51
Italy	0.00	0.38	-0.08	0.20	0.47	0.00	-0.62	-0.70	-1.22	-0.58
EU	0.00	0.39	0.07	0.35	0.51	0.00	-0.74	-0.71	-1.36	-0.67

Other alcoholic beverages – effects on non-EU countries (σ=7)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.34	-0.73	-0.40	0.47	0.00	1.29	-6.62	-5.67	1.73
Australia	0.00	0.01	-1.28	-1.33	0.01	0.00	0.66	-8.53	-8.16	0.83
New Zealand	0.00	0.04	-1.23	-1.20	0.00	0.00	0.16	-1.76	-1.70	0.15
Chile	0.00	0.08	-0.47	-0.38	0.09	0.00	0.27	-2.37	-2.20	0.31
Israel	0.00	0.31	1.88	2.25	0.22	0.00	0.77	0.29	1.01	0.68
Switzerland	0.00	0.79	1.87	2.65	0.78	0.00	0.87	1.02	1.84	0.81
China	0.00	0.07	-2.96	-2.99	0.08	0.00	0.29	-6.02	-5.94	0.36
Brazil	0.00	0.46	-0.94	-0.38	0.61	0.00	0.28	-1.63	-1.34	0.36
Thailand	0.00	0.13	20.61	21.16	0.14	0.00	0.13	10.85	11.41	0.15
India	0.00	0.17	8.97	8.78	0.21	0.00	0.25	66.30	67.95	0.26
Canada	0.00	0.02	1.02	1.12	0.03	0.00	0.13	0.08	0.19	0.17
Argentina	0.00	0.12	-0.23	-0.13	0.17	0.00	0.15	-0.57	-0.45	0.19
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	6.43	-13.72	-8.97	8.88	0.00	2.46	30.81	36.51	13.15
Australia	0.00	6.35	11.62	16.98	8.71	0.00	2.63	97.12	107.04	13.47
New Zealand	0.00	6.31	-18.59	-14.32	8.62	0.00	2.20	35.45	41.60	-5.53
Chile	0.00	6.68	-13.45	-8.57	9.16	0.00	2.09	37.14	42.94	6.81
Israel	0.00	6.60	0.68	6.14	8.85	0.00	0.32	36.69	40.04	-8.43
Switzerland	0.00	8.22	-0.78	5.97	10.98	0.00	-1.86	16.41	17.04	-9.43
China	0.00	6.48	-0.89	3.96	8.88	0.00	2.15	47.24	54.35	12.92
Brazil	0.00	6.82	40.68	48.04	9.36	0.00	1.73	33.11	38.22	11.90
Thailand	0.00	7.04	1023.35	1055.34	9.56	0.00	2.30	87.71	99.02	8.17
India	0.00	7.38	1639.67	1660.03	10.13	0.00	2.00	140.37	154.27	10.20
Canada	0.00	6.35	-23.70	-19.60	8.77	0.00	2.34	40.02	46.59	11.26
Argentina	0.00	6.96	48.75	56.71	9.55	0.00	1.89	26.94	31.99	12.52
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.00	0.20	0.20	0.00	0.00	-0.08	0.40	0.34	-0.11
Australia	0.00	-0.01	-1.39	-1.48	-0.02	0.00	-0.05	2.74	2.81	-0.06
New Zealand	0.00	-0.03	0.00	-0.03	-0.04	0.00	-0.13	2.85	2.83	-0.12
Chile	0.00	0.03	-0.20	-0.19	0.03	0.00	-0.15	1.86	1.78	-0.18
Israel	0.00	-0.04	0.18	0.13	-0.05	0.00	-0.49	0.09	-0.33	-0.43
Switzerland	0.00	0.16	0.47	0.57	0.21	0.00	-0.92	-0.26	-1.04	-0.89
China	0.00	0.00	-1.30	-1.38	-0.01	0.00	-0.14	4.68	4.72	-0.17
Brazil	0.00	0.04	-1.75	-1.80	0.05	0.00	-0.22	2.67	2.51	-0.29
Thailand	0.00	0.09	-10.63	-10.96	0.10	0.00	-0.11	10.61	10.91	-0.13
India	0.00	0.13	-22.48	-23.01	0.17	0.00	-0.17	15.04	15.21	-0.21
Canada	0.00	-0.02	0.59	0.60	-0.02	0.00	-0.11	0.31	0.23	-0.14
Argentina	0.00	0.06	-1.91	-1.94	0.08	0.00	-0.19	1.69	1.56	-0.25
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.00	0.07	-0.34	-0.29	0.10	0.00	0.07	-0.54	-0.49	0.10
Australia	0.00	0.04	-2.29	-2.35	0.05	0.00	0.06	-0.92	-0.89	0.07
New Zealand	0.00	0.11	-2.38	-2.36	0.10	0.00	0.14	-2.38	-2.33	0.14
Chile	0.00	0.13	-1.56	-1.50	0.15	0.00	0.11	-1.36	-1.31	0.12
Israel	0.00	0.42	-0.08	0.29	0.37	0.00	0.46	-0.26	0.16	0.42
Switzerland	0.00	0.79	0.23	0.90	0.77	0.00	0.64	-0.24	0.32	0.56
China	0.00	0.12	-3.84	-3.87	0.14	0.00	0.12	-2.57	-2.52	0.15
Brazil	0.00	0.19	-2.23	-2.09	0.25	0.00	0.15	-0.49	-0.30	0.20
Thailand	0.00	0.10	-8.26	-8.47	0.11	0.00	0.01	2.67	2.82	0.01
India	0.00	0.15	-11.17	-11.28	0.18	0.00	0.02	14.61	15.26	0.01
Canada	0.00	0.09	-0.27	-0.19	0.12	0.00	0.11	-0.85	-0.79	0.14
Argentina	0.00	0.17	-1.43	-1.32	0.21	0.00	0.10	0.49	0.63	0.13

Tobacco – effects on the UK and EU countries (σ=3.4)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	4.31	-10.20	4.31	-10.20	-7.98	5.20	-10.62	5.20	-10.60	-7.05
Netherlands	0.30	-0.30	0.33	-0.26	-0.11	0.29	-0.07	0.32	-0.02	0.04
Ireland	0.29	-0.25	0.33	-0.20	-0.17	0.32	-0.05	0.35	-0.01	0.08
France	0.19	0.02	0.23	0.07	0.10	0.28	-0.09	0.31	-0.05	0.02
Germany	0.26	-0.16	0.29	-0.11	-0.01	0.23	-0.01	0.27	0.03	0.07
Spain	0.15	0.11	0.19	0.16	0.18	0.21	-0.01	0.24	0.03	0.07
Belgium-Lux.	0.20	-0.01	0.24	0.04	0.11	0.29	-0.07	0.32	-0.03	0.04
Italy	0.13	0.17	0.17	0.23	0.25	0.18	0.02	0.22	0.06	0.09
EU	0.19	0.00	0.23	0.05	0.11	0.22	0.00	0.25	0.04	0.08
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	8.12	-17.80	8.27	-17.60	-14.45	6.37	-15.24	5.96	-15.72	-12.02
Ireland	8.00	-17.56	8.15	-17.36	-14.33	6.27	-14.98	5.87	-15.46	-11.78
France	8.05	-17.63	8.22	-17.42	-14.35	6.36	-15.27	5.95	-15.75	-12.04
Germany	8.11	-17.76	8.28	-17.55	-14.43	6.36	-15.32	5.95	-15.80	-12.08
Spain	8.07	-17.63	8.24	-17.42	-14.35	6.37	-15.39	5.95	-15.88	-12.14
Belgium-Lux.	8.09	-17.74	8.25	-17.54	-14.41	6.37	-15.25	5.97	-15.73	-12.03
Italy	8.10	-17.68	8.27	-17.47	-14.38	6.38	-15.44	5.96	-15.93	-12.19
EU	8.09	-17.71	8.26	-17.50	-14.39	6.36	-15.31	5.96	-15.79	-12.08
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-4.43	10.79	-4.55	10.56	-7.73	-3.77	9.86	-3.72	9.98	12.39
Netherlands	0.00	0.10	0.02	0.12	0.14	0.00	0.33	-0.01	0.32	0.25
Ireland	-0.06	0.27	-0.04	0.30	0.24	-0.05	0.51	-0.06	0.50	0.42
France	-0.03	0.18	-0.01	0.21	0.18	0.00	0.30	-0.02	0.29	0.24
Germany	0.00	0.11	0.02	0.13	0.14	0.00	0.27	-0.01	0.26	0.21
Spain	-0.02	0.15	0.00	0.18	0.16	0.01	0.22	-0.01	0.20	0.17
Belgium-Lux.	-0.01	0.12	0.01	0.15	0.15	0.01	0.32	-0.01	0.31	0.25
Italy	-0.01	0.12	0.02	0.15	0.14	0.01	0.19	-0.01	0.17	0.14
EU	-0.01	0.13	0.01	0.16	0.15	0.00	0.26	-0.02	0.24	0.20
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	2.75	-6.42	2.71	-6.49	-7.91	7.51	-15.52	7.61	-15.42	-0.20
Netherlands	0.00	-0.23	0.01	-0.22	-0.18	0.00	-0.33	-0.01	-0.35	-0.32
Ireland	0.03	-0.36	0.04	-0.35	-0.29	0.10	-0.63	0.08	-0.65	-0.53
France	0.00	-0.21	0.01	-0.21	-0.17	0.03	-0.39	0.02	-0.41	-0.35
Germany	0.00	-0.19	0.01	-0.18	-0.15	0.00	-0.30	-0.01	-0.31	-0.29
Spain	0.00	-0.15	0.01	-0.14	-0.12	0.02	-0.30	0.01	-0.32	-0.28
Belgium-Lux.	-0.01	-0.22	0.00	-0.22	-0.17	0.01	-0.35	-0.01	-0.37	-0.33
Italy	-0.01	-0.13	0.01	-0.12	-0.10	0.00	-0.25	-0.01	-0.26	-0.24
EU	0.00	-0.18	0.01	-0.17	-0.14	0.01	-0.31	0.00	-0.33	-0.29

Tobacco – effects on non-EU countries (σ=3.4)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	-0.03	0.47	0.13	0.68	0.58	-0.04	0.25	0.11	0.41	0.34
Australia	0.04	0.25	0.08	0.32	0.29	0.00	0.17	0.00	0.18	0.22
New Zealand	0.03	0.26	0.11	0.36	0.29	0.01	0.14	0.08	0.24	0.18
Chile	-0.01	0.32	0.05	0.40	0.21	0.01	0.20	0.06	0.26	0.11
Israel	0.04	0.28	0.04	0.29	0.14	0.01	0.29	0.00	0.29	0.12
Switzerland	-0.05	0.61	0.36	1.13	0.76	0.00	0.38	0.29	0.71	0.48
China	0.03	0.31	0.12	0.42	0.33	-0.01	0.14	0.08	0.25	0.17
Brazil	-0.09	0.59	0.08	0.81	0.64	0.01	0.19	0.08	0.27	0.21
Thailand	0.03	0.22	0.08	0.21	0.23	0.00	0.12	0.06	0.25	0.14
India	0.00	0.39	0.24	0.68	0.47	0.01	0.16	0.08	0.25	0.20
Canada	0.02	0.30	0.07	0.38	0.35	0.00	0.19	0.06	0.25	0.25
Argentina	0.00	0.30	0.08	0.40	0.32	0.01	0.18	0.07	0.25	0.20
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	-6.29	17.56	4.86	31.68	22.23	-7.80	19.52	2.43	32.46	29.41
Australia	-6.24	17.39	-26.95	-8.41	22.00	-7.83	19.58	-8.37	18.64	28.98
New Zealand	-6.25	17.45	-2.56	22.19	22.06	-7.83	19.58	17.42	52.02	27.82
Chile	-6.32	17.61	-1.90	23.29	22.06	-7.78	19.53	-6.59	20.83	-21.36
Israel	-6.22	17.23	-16.50	4.48	21.60	-7.76	19.59	-17.67	6.26	-22.58
Switzerland	-6.27	17.30	20.38	50.77	22.07	-7.69	19.55	17.94	52.28	29.02
China	-6.24	17.44	4.06	30.46	22.04	-7.86	19.60	1.52	31.63	19.37
Brazil	-6.35	17.71	-3.37	21.61	22.34	-7.79	19.54	1.54	31.47	19.30
Thailand	-6.25	17.47	101.33	152.07	22.07	-7.86	19.59	1.98	32.34	19.77
India	-6.26	17.44	22.12	53.08	22.11	-7.82	19.58	10.50	42.92	29.51
Canada	-6.26	17.44	-25.20	-6.14	22.08	-7.79	19.52	0.01	28.91	29.41
Argentina	-6.31	17.60	-0.87	24.57	22.20	-7.80	19.55	1.83	31.88	19.63
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	0.01	0.08	0.03	0.09	0.09	0.02	-0.08	-0.03	-0.14	-0.11
Australia	0.03	0.03	0.12	0.14	0.02	0.00	-0.05	-0.02	-0.07	-0.07
New Zealand	0.02	0.05	0.04	0.07	0.05	0.00	-0.05	-0.07	-0.12	-0.06
Chile	0.00	0.10	0.04	0.14	0.09	0.03	-0.08	0.00	-0.10	0.08
Israel	0.05	-0.03	0.11	0.05	-0.04	0.05	-0.05	0.08	0.01	0.17
Switzerland	0.04	-0.01	-0.01	-0.08	0.02	0.09	-0.07	-0.09	-0.30	-0.15
China	0.02	0.05	0.03	0.05	0.05	-0.02	-0.04	-0.04	-0.06	-0.03
Brazil	-0.01	0.13	0.04	0.20	0.14	0.03	-0.07	-0.03	-0.13	-0.06
Thailand	0.02	0.06	-0.12	-0.13	0.06	-0.02	-0.05	0.02	0.05	-0.03
India	0.02	0.05	0.00	0.01	0.06	0.01	-0.05	-0.05	-0.10	-0.07
Canada	0.03	0.04	0.13	0.17	0.04	0.02	-0.08	-0.01	-0.12	-0.11
Argentina	0.00	0.10	0.04	0.14	0.10	0.02	-0.07	-0.02	-0.11	-0.06
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	-0.01	0.06	0.02	0.10	0.08	-0.02	-0.02	-0.01	0.01	-0.01
Australia	0.00	0.04	0.01	0.05	0.05	-0.03	0.01	-0.11	-0.10	0.02
New Zealand	0.00	0.04	0.05	0.08	0.04	-0.02	-0.01	0.00	0.01	-0.01
Chile	-0.02	0.05	0.00	0.07	-0.06	-0.02	-0.05	-0.04	-0.07	-0.14
Israel	-0.03	0.03	-0.05	-0.01	-0.12	-0.08	0.06	-0.16	-0.06	-0.08
Switzerland	-0.06	0.05	0.06	0.21	0.10	-0.10	0.06	0.07	0.30	0.08
China	0.01	0.03	0.03	0.04	0.02	-0.01	-0.02	0.00	-0.01	-0.03
Brazil	-0.02	0.05	0.02	0.10	0.05	-0.01	-0.08	-0.02	-0.11	-0.10
Thailand	0.01	0.03	-0.02	-0.04	0.02	-0.01	-0.02	0.10	0.10	-0.03
India	0.00	0.04	0.04	0.07	0.05	-0.03	-0.01	0.04	0.07	-0.01
Canada	-0.02	0.06	0.01	0.08	0.08	-0.04	0.02	-0.12	-0.08	0.04
Argentina	-0.01	0.05	0.02	0.08	0.04	-0.02	-0.05	-0.02	-0.06	-0.06

Other products – effects on the UK and EU countries (σ=3)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.97	-4.12	1.35	-3.69	-3.39	1.14	-5.89	1.57	-5.39	-4.27
Netherlands	0.12	-0.85	0.08	-0.89	-1.09	0.08	-0.44	0.09	-0.42	-1.18
Ireland	0.32	-1.72	0.29	-1.76	-1.69	0.12	-0.84	0.08	-0.87	-2.28
France	0.04	-0.38	0.03	-0.39	-0.80	0.04	-0.29	0.05	-0.28	-0.95
Germany	0.02	-0.31	0.01	-0.32	-0.77	0.04	-0.27	0.05	-0.25	-0.89
Spain	0.03	-0.31	0.03	-0.31	-0.70	0.03	-0.24	0.06	-0.22	-0.83
Belgium-Lux.	0.01	-0.30	0.00	-0.32	-0.78	0.03	-0.24	0.05	-0.23	-0.94
Italy	0.01	-0.24	0.01	-0.25	-0.69	0.03	-0.22	0.05	-0.20	-0.77
EU	0.03	-0.35	0.03	-0.36	-0.77	0.04	-0.27	0.05	-0.25	-0.89
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Netherlands	2.26	-10.70	1.74	-11.17	-8.89	1.70	-9.06	1.35	-9.45	-8.27
Ireland	2.15	-10.14	1.72	-10.55	-8.45	1.37	-7.70	1.04	-8.07	-7.83
France	2.21	-10.39	1.71	-10.84	-8.72	1.71	-9.18	1.35	-9.57	-8.25
Germany	2.23	-10.53	1.73	-11.00	-8.82	1.73	-9.25	1.37	-9.64	-8.29
Spain	2.19	-10.25	1.70	-10.69	-8.65	1.74	-9.34	1.37	-9.74	-8.28
Belgium-Lux.	2.26	-10.72	1.74	-11.20	-8.91	1.72	-9.14	1.37	-9.52	-8.31
Italy	2.19	-10.29	1.71	-10.74	-8.69	1.75	-9.39	1.38	-9.79	-8.29
EU	2.21	-10.43	1.72	-10.89	-8.74	1.67	-8.99	1.32	-9.37	-8.22
	% change in inward multilateral remoteness					% change in outward multilateral remoteness				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	-1.07	7.34	-1.40	6.93	-4.56	-0.93	3.16	-1.23	2.85	4.44
Netherlands	0.01	-0.26	-0.01	-0.28	-0.33	-0.13	0.95	-0.03	1.07	0.17
Ireland	-0.12	0.43	-0.10	0.44	0.03	-0.37	2.08	-0.26	2.22	0.53
France	-0.01	-0.11	-0.03	-0.13	-0.24	-0.12	0.86	-0.03	0.96	0.19
Germany	0.01	-0.21	-0.01	-0.24	-0.30	-0.10	0.80	-0.01	0.91	0.15
Spain	-0.02	-0.08	-0.03	-0.10	-0.21	-0.10	0.72	-0.02	0.82	0.17
Belgium-Lux.	0.02	-0.29	-0.01	-0.32	-0.36	-0.11	0.89	-0.02	1.00	0.14
Italy	-0.01	-0.12	-0.02	-0.14	-0.23	-0.09	0.68	-0.01	0.78	0.16
EU	-0.01	-0.14	-0.02	-0.16	-0.25	-0.11	0.80	-0.02	0.90	0.17
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
United Kingdom	0.63	-2.05	0.83	-1.86	-2.86	1.71	-8.75	2.26	-8.21	1.79
Netherlands	0.08	-0.63	0.02	-0.70	-0.11	0.07	-0.38	0.03	-0.42	0.22
Ireland	0.25	-1.37	0.17	-1.45	-0.35	0.37	-1.79	0.27	-1.89	-0.38
France	0.08	-0.57	0.02	-0.64	-0.13	0.09	-0.46	0.05	-0.51	0.11
Germany	0.07	-0.53	0.01	-0.60	-0.10	0.06	-0.32	0.02	-0.36	0.20
Spain	0.07	-0.48	0.01	-0.54	-0.11	0.08	-0.40	0.04	-0.45	0.10
Belgium-Lux.	0.07	-0.59	0.01	-0.66	-0.09	0.06	-0.30	0.02	-0.34	0.27
Italy	0.06	-0.45	0.00	-0.52	-0.11	0.07	-0.34	0.02	-0.38	0.12
EU	0.07	-0.53	0.01	-0.60	-0.11	0.08	-0.39	0.04	-0.44	0.14

Other products– effects on non-EU countries (σ=3)

	% change in imports					% change in exports				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	-0.10	0.59	0.20	0.93	0.24	-0.04	0.23	0.14	0.43	0.27
Australia	-0.05	0.29	0.01	0.36	0.04	-0.02	0.14	0.02	0.19	0.11
New Zealand	-0.06	0.34	0.15	0.58	0.07	-0.02	0.12	0.09	0.24	0.17
Chile	-0.05	0.27	0.05	0.38	0.00	-0.02	0.12	0.06	0.21	0.04
Israel	-0.10	0.56	-0.24	0.38	-0.50	-0.04	0.26	-0.16	0.12	-0.55
Switzerland	-0.06	0.23	0.00	0.30	-0.36	-0.02	0.12	0.05	0.20	-0.37
China	-0.05	0.27	0.00	0.33	-0.04	-0.02	0.13	0.05	0.21	0.13
Brazil	-0.06	0.30	-0.01	0.35	0.03	-0.02	0.13	0.03	0.18	0.04
Thailand	-0.05	0.26	0.03	0.34	0.01	-0.02	0.10	0.05	0.18	0.10
India	-0.07	0.38	0.69	1.18	0.12	-0.02	0.14	0.18	0.36	0.10
Canada	-0.06	0.32	0.01	0.40	0.09	-0.02	0.12	-0.01	0.14	0.13
Argentina	-0.06	0.30	0.01	0.38	0.07	-0.02	0.10	0.03	0.16	0.09
	% change in imports from the UK					% change in exports to the UK				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	-1.29	4.55	1.73	7.76	5.98	-1.47	12.55	7.81	23.01	15.66
Australia	-1.28	4.47	-9.31	-4.02	5.91	-1.48	12.63	1.40	15.80	15.58
New Zealand	-1.30	4.57	0.47	6.46	5.98	-1.47	12.63	11.28	27.07	15.35
Chile	-1.29	4.51	-1.25	4.55	5.88	-1.48	12.66	6.34	21.47	11.87
Israel	-1.27	4.37	-5.03	0.36	5.20	-1.48	12.67	-7.01	6.28	-11.20
Switzerland	-1.17	3.53	5.77	10.78	5.27	-1.50	13.01	1.33	16.15	9.48
China	-1.27	4.39	5.89	11.95	5.82	-1.49	12.76	0.77	15.22	14.34
Brazil	-1.29	4.47	3.14	9.15	5.89	-1.48	12.66	-0.67	13.48	13.35
Thailand	-1.28	4.44	15.77	22.46	5.88	-1.49	12.75	0.56	14.98	15.38
India	-1.28	4.44	131.39	144.55	5.94	-1.48	12.66	3.65	18.41	17.33
Canada	-1.30	4.64	8.64	15.23	6.08	-1.47	12.56	-4.41	9.03	14.86
Argentina	-1.31	4.60	3.35	9.52	5.97	-1.47	12.65	0.20	14.45	15.36
	% change in inward MR					% change in outward MR				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	-0.01	0.08	0.01	0.11	-0.03	0.03	-0.21	-0.09	-0.34	-0.11
Australia	-0.01	0.06	0.07	0.15	-0.05	0.03	-0.16	0.01	-0.17	-0.06
New Zealand	-0.02	0.11	0.04	0.17	0.01	0.03	-0.15	-0.09	-0.28	0.03
Chile	-0.02	0.09	-0.01	0.09	-0.04	0.03	-0.14	-0.03	-0.19	-0.01
Israel	-0.01	0.02	-0.01	0.01	-0.28	0.02	-0.13	0.11	-0.01	0.25
Switzerland	0.04	-0.31	-0.06	-0.41	-0.40	0.00	0.10	0.01	0.11	-0.22
China	-0.01	0.05	-0.03	0.03	-0.05	0.02	-0.07	0.06	-0.02	0.07
Brazil	-0.02	0.07	-0.03	0.05	-0.05	0.03	-0.14	0.05	-0.10	-0.06
Thailand	-0.02	0.07	-0.05	0.03	-0.02	0.02	-0.08	0.07	-0.02	0.08
India	-0.01	0.06	-0.81	-0.79	-0.04	0.02	-0.13	0.09	-0.06	-0.08
Canada	-0.02	0.13	0.01	0.17	0.04	0.03	-0.20	0.03	-0.20	-0.05
Argentina	-0.02	0.13	-0.03	0.12	0.01	0.03	-0.14	0.06	-0.10	0.02
	% change in price (factory gate)					% change in real income				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
USA	-0.02	0.14	0.06	0.23	0.07	-0.01	0.06	0.05	0.12	0.11
Australia	-0.02	0.10	-0.01	0.11	0.04	-0.01	0.04	-0.07	-0.03	0.08
New Zealand	-0.02	0.10	0.06	0.19	-0.02	0.00	-0.01	0.02	0.01	-0.03
Chile	-0.02	0.09	0.02	0.13	0.01	0.00	0.00	0.03	0.04	0.05
Israel	-0.02	0.09	-0.08	0.01	-0.17	-0.01	0.07	-0.06	0.00	0.11
Switzerland	0.00	-0.06	-0.01	-0.07	0.15	-0.04	0.24	0.05	0.34	0.55
China	-0.01	0.05	-0.04	0.02	-0.05	0.00	0.00	-0.01	-0.01	0.00
Brazil	-0.02	0.09	-0.03	0.07	0.04	0.00	0.02	0.00	0.02	0.09
Thailand	-0.01	0.05	-0.05	0.01	-0.05	0.00	-0.02	0.01	-0.02	-0.03
India	-0.02	0.09	-0.06	0.04	0.05	-0.01	0.03	0.75	0.83	0.09
Canada	-0.02	0.13	-0.02	0.13	0.03	0.00	0.01	-0.03	-0.04	-0.01
Argentina	-0.02	0.10	-0.04	0.07	-0.02	0.01	-0.03	-0.01	-0.05	-0.02

Notes: Computations by authors. (S1) EU-UK FTA & the UK replicates EU's PTA with third countries; (S2) No EU-UK trade deal & the UK replicates the EU's PTAs with third countries; (S3) EU-UK FTA & the UK signs PTA with six main third trade partners; (S4) No EU-UK trade deal & the UK signs PTA with six main third trade partners; (S5) Unilateral liberalization of the British market.

Chapter III

Brexit et exportations agricoles et alimentaires Bretonnes: quelle relation B2B ? [1]

1. Une version de ce chapitre co-écrit avec Angela Cheptea et Marilyne Huchet est soumise à publication dans la revue *"Economie et Statistique"*.

1 Introduction

Des liens vieux de plusieurs siècles existent entre la Bretagne et le Royaume-Uni. Au Vème siècle, avec la chute de l'Empire romain d'Occident, la Bretagne alors appelée l'Armorique est envahie par les Angles et les Saxons. Un grand nombre de Britanniques du Sud-Ouest s'installe en Armorique et lui donne le nom de Petite Bretagne, ou Bretagne continentale, par opposition à leur île d'origine, la Bretagne insulaire. Ils apportent également leurs coutumes et leur langue. Ces liens historiques entre les deux Bretagnes et cette proximité culturelle a laissé des traces jusqu'à nos jours, par exemple avec les langues brittoniques (le breton, le cornique et le gallois, parlés en Bretagne, en Cornouailles et au Pays de Galle [2]) ou les liens commerciaux étroits (Abalain, 2000).

Le XXème siècle voit la modernisation de l'agriculture bretonne grâce à plusieurs facteurs, notamment la mécanisation, l'apport d'engrais phosphatés et la modernisation des moyens de transport (essor du rail puis de la route). Les productions agricoles se diversifient et les exportations se développent, en particulier avec le Royaume-Uni, un partenaire historique. Par exemple, les producteurs d'oignons de la région de Roscoff exportent leurs produits en Angleterre dès 1828 [3]. Plus généralement, l'arrivée du chemin de fer permet un acheminement plus rapide des productions, notamment vers Paris. Le modèle industriel breton demeure encore aujourd'hui regroupé autour de quatre grands pôles que sont l'agro-alimentaire, la fabrication d'appareils électriques et électroniques, l'industrie automobile et la construction navale. Depuis les années 196, économie de la Bretagne est fortement tournée 0 vers l'agriculture et les industries agro-alimentaires. Bien que la Bretagne soit avant tout une région d'élevage, elle est aussi la première région légumière de France [4]. Il s'agit surtout d'une agriculture diversifiée et productive avec une dominante d'élevage. À titre d'exemple, en 2018, la Bretagne a produit 35 390 tonnes de veaux de boucherie, 216 500 tonnes de choux-fleurs et 169 500 tonnes de tomates [5].

La sortie des britanniques de l'Union Européenne soulève de nombreuses interrogations concernant l'avenir des relations commerciales entre le Royaume-Uni et la Bretagne, mais aussi la France en général, pour plusieurs raisons. D'une part, le Royaume-Uni est un partenaire historiquement privilégié de la Bretagne dans le commerce agro-alimentaire. D'après les données des douanes régionales, la Bretagne dégage en 2015 un excédent commercial agro-alimentaire avec le Royaume-Uni de 99 millions d'euros. D'autre part, l'accord de divorce entre le Royaume-Uni et l'Union Européenne est en cours de négociation, et l'issue reste incertaine. Une phase de transition est prévue jusqu'à fin 2020 mais elle pourrait aller au-delà. Des négociations majeures sur les futures relations commerciales

2. Le breton est aujourd'hui encore parlé par environ 12% des bretons, http://www.epsilon.insee.fr
3. http://oignonderoscoff.fr
4. http://www.chambres-agriculture-bretagne.fr
5. http://www.chambres-agriculture-bretagne.fr

entre le Royaume-Uni et les 27 pays de l'Union Européenne, –d'important partenaires commerciaux– mais également entre le Royaume-Uni et les pays hors Union Européenne, ont lieu pendant cette phase de transition. En particulier, il est probable que l'on assiste à un rétablissement total ou partiel de barrières tarifaires et non tarifaires entre le Royaume-Uni et l'Union Européenne (connu dans la littérature comme un retour aux règles de l'Organisation Mondiale du Commerce). Les nouvelles règles commerciales résultant de ces négociations pourront générer des phénomènes de création et/ou de détournement de commerce. L'impact des nouveaux accords sera particulièrement fort sur les échanges internationaux du secteur agricole et alimentaire, marqué par un haut niveau de protection au sein de l'Union Européenne.

Les conséquences du Brexit sur les flux commerciaux entre le Royaume-Uni et les pays de l'Union Européenne ont été abondamment étudiées ces dernières années (par exemple Dhingra et al. (2017) pour le Royaume-Uni, Bellora et al. (2017) et Cheptea and Huchet (2019) pour l'Union Européenne). La littérature révèle davantage d'études consacrées à la mesure des impacts sur le commerce agro-alimentaire pour le Royaume-Uni relativement aux autres pays européens, y compris la France. Nous proposons ici de mesurer les impacts sur le commerce agro-alimentaire breton. Deux études, CESER (2017) et CESER (2016), s'intéressent aux impacts du Brexit sur la Bretagne de façon plus générale et qualitative, pas uniquement en termes commercial ni agro-alimentaire.

À un échelon régional, une analyse des impacts sur le commerce agro-alimentaire breton est primordiale. D'une part, la Bretagne est l'une des principales régions françaises en termes de production agricole (même après la réforme territoriale de 2015) et la première en termes de chiffre d'affaires de l'industrie agro-alimentaire. D'autre part, le Royaume-Uni est un client privilégié de la Bretagne (8% des exportations agro-alimentaires bretonnes, 5ème place derrière l'Italie, l'Espagne, la Chine et la Belgique en 2015). En outre, la conclusion de nouveaux accords entre le Royaume-Uni et des pays tiers tels que les États-Unis ou les pays du Commonwealth réduirait les barrières commerciales entre ces pays et le Royaume-Uni. Cette ouverture du marché britannique vers des pays tiers pourrait priver les produits français et bretons de l'accès préférentiel dont ils jouissaient avant le Brexit, menant à l'érosion des parts de marché et à la nécessité de trouver de nouveaux débouchés.

Le présent travail vise à quantifier les effets de différents scénarios de politique commerciale sur les principaux groupes de produits agricoles et alimentaires exportés par la Bretagne. Les études au niveau des régions sous-nationales sont rares et s'intéressent généralement aux effets sur l'ensemble de l'économie, sans différentiation par secteur ou type de produits. Par exemple, on trouve deux études régionales européennes dans la littérature: Chen et al. (2018) proposent un indice d'exposition pour quantifier la vulnérabilité des régions et des pays de l'Union Européenne par rapport au Brexit, et Capello et al. (2018) mesurent

les pertes en termes de croissance de produit intérieur brut (PIB) qu'engendrerait une réintroduction de barrières légales et administratives, au niveau des différentes régions d'Europe. Fait encore plus marquant, il n'y a pas d'étude mesurant les impacts sur le commerce agro-alimentaire breton, une lacune que nous proposons ici de combler. Par ailleurs, nous présentons une méthodologie permettant d'obtenir de façon indirecte les données intra- et inter-régionales qui peuvent faire défaut lorsque l'on souhaite mener une étude avec un modèle se basant sur les flux commerciaux entre pays ou régions. Ce papier constitue donc un important apport méthodologique qui vise à pallier un manque de données régionales qui limitait jusque-là les études régionales.

La Section 2 présente les faits stylisés. Nous mettons en lumière les produits phares pour la Bretagne, autant pour la production que pour le commerce agricoles et agro-alimentaires. Nous précisons quels sont les plus grands partenaires commerciaux pour la Bretagne en agro-alimentaire. Dans la Section 3 nous présentons la méthode utilisée ainsi que les scénarios envisagés. La Section 4 présente les données disponibles ainsi que les résultats de la reconstitution des données manquantes et les tests de robustesse. Dans la Section 5 nous présentons les résultats de la simulation des scénarios en termes de variation de flux commerciaux. La discussion et la conclusion sont proposées en Section 6.

2 La Bretagne agricole et agro-alimentaire: produits phares et partenaires commerciaux privilégiés

Dans cette section nous présentons majoritairement les chiffres de l'année 2015, qui correspond à l'année qui précède le référendum mené en juin 2016 en vue de la sortie du Royaume-Uni de l'Union Européenne, autrement dit le Brexit. Par la suite, le terme *"alimentaire"* englobera l'agriculture, la pêche et les industries agro-alimentaires (IAA).

2.1 Production alimentaire bretonne

La Bretagne est une région française de premier plan en termes de production agricole et de chiffre d'affaires des industries agro-alimentaires. En effet, la Bretagne est la 1ère région française d'élevage, et c'est aussi une région légumière de premier plan. Selon Agreste, les fruits et légumes phares de la production bretonne sont tout d'abord les tomates (240 063 tonnes en 2016) suivies des choux-fleurs (236 805 t), des échalotes (36 607 t), des artichauts (26 136 t), des laitues (13 802 t), des poireaux (8 734 t), des endives (7 301 t), des choux-pommés (7 168 t), des fraises (4 281 t) et enfin des oignons de couleur (3 613 t)[6]. La Bretagne produisait, en 2015, 49% des oeufs, 26% des porcins, 27% des volailles, 21% du lait de vache, 20% des veaux et 19% des légumes frais français. Les industries agro-alimentaires bretonnes contribuent à hauteur de 8% au total de la valeur ajoutée

6. Comptes de l'agriculture 2015 DRAAF et http://agreste.agriculture.gouv.fr

(VA) des industries agro-alimentaires françaises [7]. En particulier, la Figure 1 met en valeur l'importance du poids des IAA bretonnes dans la production des aliments pour animaux et de l'industrie du poisson (avec 21% de la valeur ajoutée française), de l'industrie des viandes (20%) et de la transformation des fruits et légumes (15%).

La comparaison de la structure de l'économie bretonne et française nous montre que le secteur alimentaire pèse lourd dans l'emploi et les richesses produites par la Bretagne: le poids de la valeur ajoutée alimentaire bretonne dans l'ensemble de la valeur ajoutée bretonne est bien plus élevé que ce même poids au niveau national. La Figure 2 présente cette répartition en séparant l'alimentaire en deux catégories. Les IAA bretonnes représentent 6,6% de la valeur ajoutée bretonne alors qu'au niveau national, les IAA françaises représentent seulement 2,4% de la valeur ajoutée totale. Pour l'agriculture et la pêche, ces proportions sont respectivement 3,3% et 1,7%. Selon l'INSEE (Institut National de la Statistique et des Études Économiques), la part des emplois salariés de l'agriculture et des IAA en Bretagne est plus importante que la moyenne française: en 2014, l'agriculture comptait pour 2% des emplois salariés en Bretagne contre 1% en France métropolitaine. Pour les IAA, elle s'élevait à 6% en Bretagne et 2% en France métropolitaine.

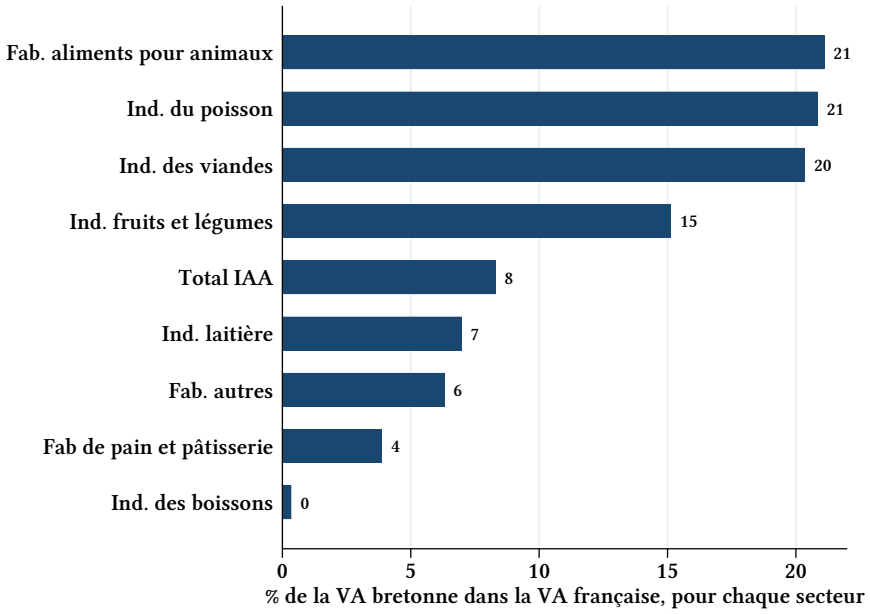
La Figure 3 détaille la répartition de la valeur ajoutée des IAA de la Bretagne et de la France. L'industrie des viandes constitue le pilier principal de l'IAA bretonne, avec 40% du chiffre d'affaires et de la valeur ajoutée de toutes les industries agro-alimentaires bretonnes, suivie par les produits laitiers et les aliments pour animaux. L'industrie des boissons est en revanche bien plus importante au niveau national qu'en Bretagne, notamment grâce aux vins. Sans surprise, l'industrie du poisson et produits de la mer est nettement plus importante en Bretagne. Rappelons que les quatre départements qui constituent la Bretagne ont une façade maritime. Le Tableau A1 en annexe détaille le chiffre d'affaires du secteur agro-alimentaire pour la Bretagne et la France.

2.2 Commerce extérieur breton: viande et produits laitiers

Tout comme la production, les produits d'exportation phares de la Bretagne ne sont pas les mêmes que ceux du niveau national. Les figures A1 et A2 en annexe indiquent que, en termes de valeur ou de pourcentage, la première catégorie exportée par la Bretagne correspond aux viandes et produits carnés (près d'1,4 milliards € en 2015 représentant près de 25% des exportations nationales de la même catégorie), suivie des produits laitiers (601 millions € en 2015 représentant 8,1% des exportations nationales de la même catégorie). Près de 12,5% des produits de la mer exportés par la France le sont par la Bretagne (234 millions € en 2015). Contrairement au reste de la France, la Bretagne ne produit et n'exporte que très peu de vin. Au niveau national, les vins sont le premier produit d'exportation (9,5 milliards € en 2015), principalement vers le Royaume-Uni et les États-Unis. Enfin, la Bretagne est large-

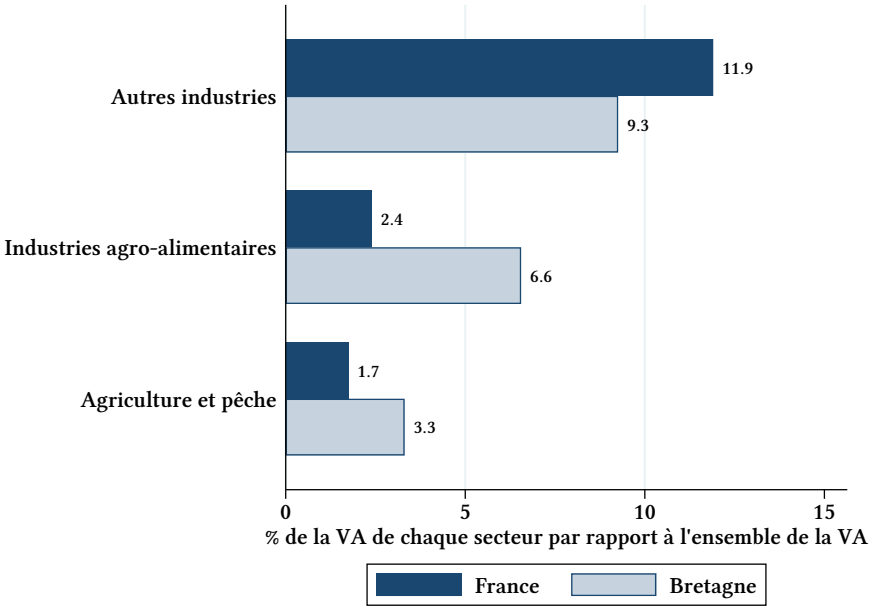
7. Source DRAFF et INSEE, année 2015

Figure 1: Contribution par secteur des IAA bretonnes dans la valeur ajoutée française, en 2015



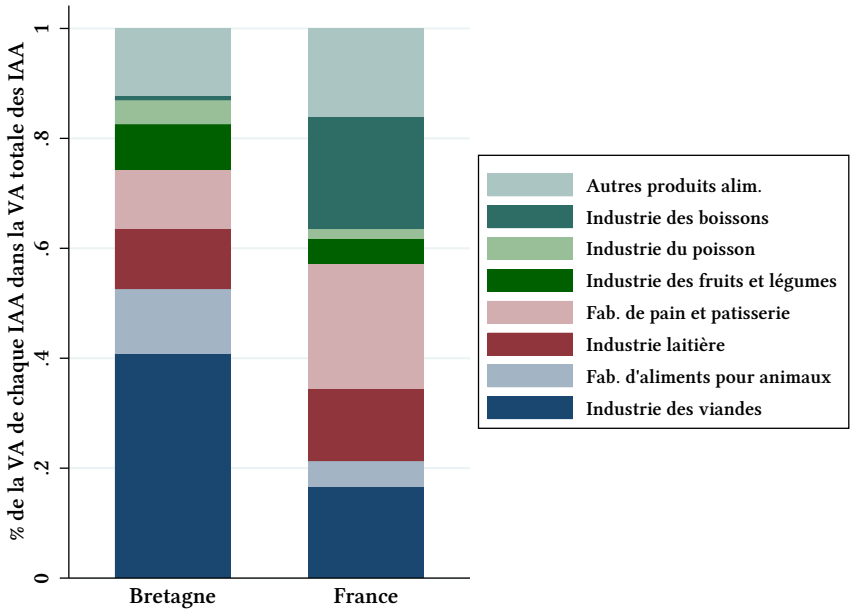
Source: INSEE, ESANE

Figure 2: Répartition de la valeur ajoutée bretonne et nationale par secteur d'activité, en 2015



Source: INSEE

Figure 3: Répartition de la valeur ajoutée des IAA bretonnes et françaises, en 2015



Source: INSEE, ESANE

ment excédentaire dans le commerce de produits agricoles et alimentaires, y compris avec le Royaume-Uni, qui est pourtant un fournisseur important de la Bretagne pour plusieurs catégories de produits. Le commerce alimentaire de la Bretagne avec le Royaume-Uni dégage un excédent commercial de 99 millions € (en 2015). La Bretagne est donc exportatrice nette avec le Royaume-Uni, qui représente un partenaire commercial majeur tant à l'import qu'à l'export.

2.3 Le Royaume-Uni, un partenaire commercial majeur de la Bretagne dans l'alimentaire: viande, fruits et légumes, céréales, produits de la mer

Des exportations bretonnes vers des destinations principalement européennes.
Avec 326 millions € en 2015, le Royaume-Uni est le 5ème destinataire des exportations alimentaires bretonnes, derrière l'Italie (439 millions € en 2015), l'Espagne (371 millions € en 2015), la Belgique-Luxembourg (365 millions € en 2015) et l'Allemagne (348 millions € en 2015) (voir la Figure A3 en annexe). La position du Royaume-Uni dans ce palmarès reste stable, on le retrouve en 5ème position en 2017, avec 387 millions € d'importations alimentaires bretonnes. Reste stable également la part du Royaume-Uni dans les exportations bretonnes, au cours des cinq dernières années, aux alentours de 8% [8]. L'ordre de ce palmarès est légèrement différent au niveau français, comme le montre la Figure A4. La Belgique, puis l'Allemagne, et enfin le Royaume-Uni arrivent en tête. Le détail selon les catégories de produits est présenté dans la Figure A5 en annexe. Les produits à base de céréales, les

8. https://www.terra.bzh/index.php/brexit-les-secteurs-surveiller-pour-les-filieres-agricoles-bretonnes

préparations de fruits et légumes, et les autres produits constituent le trio de tête. La Figure A6 en annexe donne le détail du poids de chaque catégorie de produits dans les exportations de la Bretagne et de la France vers le Royaume-Uni. Au niveau breton, ce sont les catégories de la viande et des céréales qui arrivent en tête. Au niveau national ce sont les vins qui sont exportés en majorité, suivis par les produits laitiers et les produits à base de céréales.

Les produits de la mer largement en tête des importations alimentaires bretonnes.
Le Royaume-Uni est un fournisseur alimentaire non négligeable pour la Bretagne. La Figure A7 en annexe donne le détail du poids de chaque catégorie de produits alimentaires dans les importations de la Bretagne et de la France depuis le Royaume-Uni. Les importations alimentaires bretonnes en provenance du Royaume-Uni représentent 227 millions € en 2015, dont 40% sont les produits de la pêche, 15% les viandes, et 12% les biscottes et biscuits.

2.4 La Bretagne face au Brexit

Vulnérabilité des exportations via les coûts à l'échange.
Nous avons vu que la Bretagne est nette exportatrice de produits alimentaires vers le Royaume-Uni. Les coûts d'accès au marché britannique, pour les produits bretons exportés, sont susceptibles d'augmenter, notamment suite à l'introduction potentielle de droits de douane et au rétablissement des contrôles douaniers aux frontières. Par exemple, à l'heure actuelle, des certificats sanitaires doivent accompagner tous les produits d'origine animale introduits dans l'Union Européenne en provenance d'un pays tiers. Ils sont également soumis à un contrôle documentaire. Il est aussi vérifié que le produit, les marques de salubrité, les tampons et les autres informations nécessaires sur le produit et l'emballage sont conformes à la déclaration sur les certificats sanitaires et à la législation de l'Union Européenne. Si, à l'avenir le Royaume-Uni devient un pays tiers sans accord commercial avec l'Union Européenne, non seulement ces contrôles douaniers seront rétablis pour les importations européennes en provenance du Royaume-Uni, mais aussi potentiellement pour les exportations européennes vers le Royaume-Uni. De même, les coûts de dédouanement pourraient augmenter pour certains produits alimentaires en raison de la nécessité de contrôles frontaliers supplémentaires pour garantir le respect des réglementations de l'importateur (Union Européenne ou Royaume-Uni) en matière de sécurité alimentaire et de santé animale et végétale. Le dédouanement donne lieu à deux sources de surcoûts: les frais de dédouanement en tant que tels et le retard pris lors du dédouanement des marchandises. Ces surcoûts pourront être minimisés mais difficilement évités (*cf.* détails dans Matthews, 2017b). Cette augmentation des coûts à l'échange va entraîner des modifications des flux commerciaux, non seulement entre le Royaume-Uni et ses partenaires, mais également de façon indirecte entre les partenaires, *via* par exemple le report des flux à destination du Royaume-Uni vers d'autres marchés. Par ailleurs, les nouveaux accords qui seront conclus par le Royaume-Uni pourraient réduire des coûts d'accès au marché britannique pour d'autres pays et régions, en renforçant davantage la concurrence entre ces derniers et les produits bretons. Dans la Sec-

tion 3 nous modélisons l'évolution des coûts aux échanges par une variation du niveau des mesures tarifaires (droits de douane) et mesures non tarifaires (MNT) entre le Royaume-Uni est ses principaux partenaires.

Des coûts de production faiblement impactés.
En plus des impacts sur les exportations, la variation des coûts à l'échange pourrait impacter les coûts des produits importés par les IAA bretonnes. En effet, certains intrants non alimentaires font partie des consommations intermédiaires de la production alimentaire, par exemple des emballages et des cartons. Dans le cas breton, l'augmentation des coûts à l'échange post-Brexit pourrait engendrer l'augmentation des coûts de ces produits intermédiaires et donc des coûts de production de l'alimentaire breton. Cependant, les IAA bretonnes importent peu d'intrants du Royaume-Uni – ils ne font pas partie des premiers postes d'importation de la Bretagne – on ne s'attend donc pas à une hausse des coûts de production des produits alimentaires bretons. La Figure A8 en annexe présente les importations de la Bretagne en provenance du Royaume-Uni, tous secteurs confondus, même hors alimentaire. Le poisson représente le premier poste d'importation de la Bretagne (19,3%), suivi par la viande (7,2%) et les biscuits (5,7%). Les emballages en plastique en provenance du Royaume-Uni ne comptent que pour 1,0% des importations de la Bretagne.

Une période de transition entre le Royaume-Uni et l'Union Européenne.
Un accord sur le Brexit a été conclu entre le premier ministre du Royaume-Uni, Boris Johnson, et l'Union Européenne le 17 octobre 2019. La première phase du Brexit est un accord de sortie suivi d'une période de transition, et non un accord de relations commerciales. La sortie est effective depuis le 31 janvier 2020. La période de transition, du 31 janvier au 31 décembre 2020 prévue par l'accord de divorce, a pour but d'éviter une rupture brutale pour l'économie. En effet, rien ne change concrètement pendant cette période. Le Royaume-Uni reste bénéficiaire des accords commerciaux de l'Union Européenne: les échanges entre le Royaume-Uni et l'Union Européenne continuent sans aucun coût supplémentaire. Mais une nouvelle phase périlleuse s'annonce pour les mois, voire les années à venir: celle des complexes négociations sur la future relation commerciale avec le bloc européen, principal partenaire commercial des Britanniques, pour l'après période de transition. Elles sont censées aboutir avant la fin 2020.

Nouveaux accords entre le Royaume-Uni et les pays tiers.
Le Royaume-Uni devra également négocier des accords avec les pays tiers (hors Union Européenne). L'Union Européenne a à son actif environ 40 accords de libre échange, couvrant plus de 70 pays. En tant que membre de l'Union Européenne, le Royaume-Uni n'était pas autorisé à négocier et signer indépendamment des accords commerciaux, mais pouvait commercer avec de nombreux pays avec des droits de douanes préférentiels, voire nuls, et en présence de mesures non tarifaires peu contraignantes. Depuis le jour du Brexit (*"Brexit day"*, le 31 janvier 2020), le Royaume-Uni est libre de négocier et signer des nouveaux ac-

cords. Le Royaume-Uni a ainsi signé 20 accords de *"continuité"* couvrant 50 pays ou territoires, et environ 8% du commerce britannique total. Le Royaume-Uni a par ailleurs signé des accords avec les États-Unis, l'Australie et la Nouvelle Zélande, mais il s'agit d'*"accords de reconnaissance mutuelle"* et non d'accords de libre échange. La reconnaissance mutuelle permet notamment d'améliorer les débouchés commerciaux et de fluidifier le commerce entre les signataires. Ce type d'accord engendre également d'importantes économies grâce aux contrôles accélérés et des formalités administratives allégées au moment du dédouanement [9]. Des opportunités commerciales semblent se développer entre le Royaume-Uni et les États-Unis, mais aussi avec les 53 nations du Commonwealth (y compris l'Inde, le Canada, l'Australie, la Nouvelle-Zélande), qui représente 2,7 milliards d'habitants et un PIB similaire à celui de l'Union Européenne, selon le Fond Monétaire International (FMI).

La question des frontières irlandaises.
Les modalités de la frontière entre les deux Irlandes est l'un des points clés des négociations. La situation de l'Ulster et de la Répuplique d'Irlande est délicate. D'un côté, le maintien d'une frontière trop souple serait intenable, car le Brexit va transformer la frontière entre les deux Irlandes en une frontière extérieure de l'Union Européenne. N'exercer aucun contrôle reviendrait à faire de l'Irlande une porte d'entrée détournée vers l'Union Européenne. On parle aussi de *"cheval de troie"* qui pourrait engendrer notamment l'importation de matières premières agricoles dans l'Union Européenne venant de pays tiers avec des normes sanitaires moins contraignantes. Mais à l'inverse, réimplanter des barrières strictes compromettrait l'acquis fondamental de la paix et affaiblirait l'économie de l'île. Son histoire récente est marquée par trente années de guerre civile, qui se sont conclues avec l'accord du vendredi saint en 1998. Depuis, la frontière est devenue quasiment invisible. Avec le Brexit et le retour d'une frontière stricte, de nouveaux troubles identitaires pourraient refaire surface [10]. Le gouvernement britannique a annoncé en mai 2020 que, contrairement à de précédentes annonces, des contrôles douaniers post-Brexit seront probablement mis en place entre la Grande-Bretagne et l'Irlande du Nord pour certains biens, notamment agro-alimentaires. Ce protocole devrait éviter le retour d'une frontière physique sur l'île d'Irlande à la fin de la période transitoire post-Brexit, et ainsi minimiser l'apparition de conflits. Il est par ailleurs prévu que l'Irlande du Nord fasse partie du territoire douanier du Royaume-Uni. Mais si des marchandises y transitent avant d'entrer dans l'Union Européenne, les autorités britanniques devront alors appliquer les droits de douanes de l'Union Européenne [11].

9. https://www.douane.gouv.fr
10. https://www.touteleurope.eu
11. https://www.capital.fr

3 Méthodologie et scénarios

Le présent travail vise à quantifier les effets de différents scénarios de politique commerciale sur les groupes de produits alimentaires exportés par la Bretagne. Les débouchés des négociations étant incertains, nous souhaitons estimer les effets du Brexit selon cinq scénarios de politique commerciale en utilisant un modèle de gravité structurelle en équilibre général, selon la méthode de Anderson et al. (2018). Nous allons considérer la Bretagne et le reste de la France (hors Bretagne) comme deux pays distincts.

3.1 Modèle de gravité structurelle

Nous souhaitons estimer les effets du Brexit en termes de changement dans les flux entre la Bretagne et le Royaume-Uni. En plus des changements directs, liés à la variation des coûts à l'échange après le Brexit, nous nous intéressons également aux impacts indirects de ces changements sur les autres flux *via* les ajustements des indices de prix, les niveaux de dépense et les niveaux de production. Nous construisons un modèle de gravité suivant Anderson et al. (2018). Nous supposons un modèle de demande avec un consommateur représentatif avec des préférences homothétiques maximisant une fonction d'utilité CES (constant elasticity of substitution) sous la contrainte budgétaire, et sous l'hypothèse du commerce équilibré ("*market clearance*") pour les biens de chaque origine [12]. Le problème d'optimisation du consommateur génère les dépenses suivantes pour les marchandises produites à l'origine i consommées dans la destination j:

$$X_{ijt} = Y_{it} E_{jt} \left(\frac{\tau_{ijt}}{\Pi_{it} P_{jt}} \right)^{1-\sigma} \epsilon_{ijt} \tag{1}$$

Ainsi, X_{ijt} représente la valeur des exportations du pays exportateur i vers le pays importateur j à l'année t chiffrée aux prix payés par les consommateurs du pays j, E_{jt} est la dépense dans l'année t des consommateurs du pays j pour les produits de toutes origines, Y_{it} est la valeur de la production dans l'année t des biens provenant du pays i. La variable τ_{ijt} reflète les coûts commerciaux bilatéraux entre les deux pays. La facilité d'accès au marché fait référence aux coûts d'échanges, mais pas aux coûts de production, qui sont aussi compris dans les indices Π_{it} et P_{jt}. Π_{it} représente l'accès des consommateurs mondiaux (de toutes destinations) aux produits originaires du pays i; P_{jt} représente l'accès au marché mondial (aux produits de toutes les origines) pour les consommateurs du pays j. $\sigma > 1$ est l'élasticité de substitution entre biens de différentes origines, et ϵ_{ijt} est un terme d'erreur à espérance nulle. Le terme $\left(\tau_{ijt}/\Pi_{it}P_{jt}\right)^{1-\sigma}$ reflète l'effet total des coûts commerciaux (frictions). Il est composé par trois éléments: les coûts commerciaux bilatéraux entre partenaires, τ_{ijt}, approximés dans la littérature principalement par des variables géographiques et de politique commerciale (*e.g.* distance et droits de douane), et deux termes structurels, Π_{it} et P_{jt},

12. Le market clearance signifie l'égalité de l'offre et de la demande, et implique l'absence d'excédent ou de déficit commercial, *i.e* $\sum_i X_{ijtg} = \sum_j X_{ijtg}$.

introduits par Anderson and Van Wincoop (2003), qui captent la résistance multilatérale (RML) à l'entrée (à l'importation) et à la sortie (à l'exportation). Les hypothèses du modèle (la forme CES de la fonction d'utilité, le commerce équilibré) établissent les liens entre les deux termes de résistance multilatérale et les autres variables du modèle.

Les résistances multilatérales à l'entrée et à la sortie sont souvent interprétées comme des indices de prix et sont essentielles dans l'analyse des effets d'un changement de politique commerciale. Elles s'écrivent ainsi:

$$\Pi_{it} = \sum_j \left(\frac{\tau_{ijt}}{P_{jt}}\right)^{1-\sigma} E_{jt} \tag{2}$$

$$P_{jt} = \sum_i \left(\frac{\tau_{ijt}}{\Pi_{it}}\right)^{1-\sigma} Y_{it} \tag{3}$$

Dans notre étude, le choc lié au Brexit se traduira par la variation des coûts commerciaux:

$$\begin{aligned} \tau_{ijt}^{1-\sigma} &= dist_{ij}^{\beta_1} \exp\left(contig_{ij}\right)^{\beta_2} \exp\left(langcom_{ij}\right)^{\beta_3} \exp\left(comcol_{ij}\right)^{\beta_4} \\ &\quad \left(1 + tariff_{ijt}\right)^{1-\sigma} \cdot \prod_m \exp\left[dist_MNT_{ijt}^m\right]^{\delta_m} \end{aligned} \tag{4}$$

En conformité avec la littérature sur le commerce international, nous adoptons une spécification des coûts à l'échange qui intègre la distance géographique $dist_{ij}$ (permettant de capter les coûts de transport et assimilés, qui sont en général proportionnels à la distance parcourue), la présence d'une frontière terrestre commune $contig_{ij}$, l'utilisation de la même langue $langcom_{ij}$, un passé colonial commun $comcol_{ij}$, les droits de douanes imposés par j sur les importations en provenance de i $tariff_{ijt}$ et l'écart entre les mesures non tarifaires de différents types m de deux pays $dist_MNT_{ijt}^m$.

En injectant les coûts commerciaux de l'équation (4) dans (1) et en regroupant les termes spécifiques à l'exportateur et à l'importateur nous obtenons:

$$\begin{aligned} X_{ijt} &= dist_{ij}^{\beta_1} \exp\left(contig_{ij}\right)^{\beta_2} \exp\left(langcom_{ij}\right)^{\beta_3} \exp\left(comcol_{ij}\right)^{\beta_4} \\ &\quad \left(1 + tariff_{ijt}\right)^{1-\sigma} \cdot \prod_m \exp\left[dist_MNT_{ijt}^m\right]^{\delta_m} \cdot \psi_{it}\, \chi_{jt}\, \epsilon_{ijt} \end{aligned} \tag{5}$$

L'utilisation du modèle de gravité structurelle implique un raisonnement en termes d'équilibre général et nécessite par conséquent une matrice complète de données sur toutes les variables expliquées et explicatives du modèle, y compris pour les observations correspondant aux flux domestiques (les achats de i de biens produits en i). Les pays collectent peu voire pas de données sur les flux commerciaux à l'intérieur du pays. Dans cette étude nous souhaitons en particulier pallier ce manque de données qui limitait jusque-là les études régionales (*i.e.* au niveau des régions sous-nationales). Nous proposons pour cela

un apport méthodologique original. Dans la Section 4 nous passons en revue les données manquantes pour l'étude, et explicitons notre approche pour apporter une solution à ce problème. Une fois ces données prédites, nous pouvons appliquer la stratégie d'estimation détaillée ci-dessous.

3.2 Stratégie d'estimation et scénarios

Nous estimons les effets du Brexit à partir des données sur la période 2012-2015. Nous commençons à l'année 2012, pour s'assurer que les effets de la crise économique de 2008-2009 aient été absorbés pour la plupart des pays, et terminons en 2015, l'année précédant le vote du Brexit. Le système d'équations (2) et (3) peut être résolu avec $\{\Pi_{it}, P_{jt}\}$ à un scalaire près, ce qui implique qu'une normalisation est nécessaire (Anderson and Yotov, 2010). Pour cela, nous choisissons les États-Unis comme pays de référence, c'est-à-dire que le terme de résistance multilatérale intérieure pour ce pays est normalisé à 1: $P_{Etats-Unis}$=1 pour toutes les années et tous les groupes de produits. Les États-Unis sont un partenaire commercial important pour tous les pays de notre base de données, y compris le Royaume-Uni. Dans notre base, les États-Unis ont le commerce le plus équilibré pour les produits alimentaires. La statégie d'estimation présentée dans cette section utilise des données observées ainsi que des données non-observées, sur les flux domestiques (X_{iit}) et les flux inter-régionaux dont le calcul est explicité dans la Section 4.

(1) Calcul des valeurs de référence.
La première étape est le calcul des valeurs de référence pour les variables du modèle. Nous estimons l'équation (5) sur l'ensemble de flux commerciaux (internationaux et domestiques) dans la période étudiée. Nous utilisons les valeurs estimées des paramètres $\widehat{\beta_1}$ à $\widehat{\beta_4}$ et $\widehat{\delta^m}$ et des effets fixes importateur-année et exportateur-année, $\widehat{\chi_{jt}}$ et $\widehat{\psi_{it}}$, pour calculer les valeurs de référence des termes de résistance multilatérale, P_{jt} et Π_{it} [13]. Les valeurs de référence des dépenses et des revenus annuels, E^R_{jt} et Y^R_{it}, sont obtenues en imposant les contraintes budgétaires ($E^R_{jt} = \sum_h X_{hjt}$) et l'égalité de l'offre et de la demande ($Y^R_{it} = \sum_l X_{ilt}$) pour chaque pays. La valeur estimée de l'élasticité de substitution σ n'étant pas toujours statistiquement significative, nous choisissons de fixer σ en cohérence avec les valeurs que l'on trouve dans la littérature empirique sur les échanges de produits agricoles et alimentaires [14]. Dans cette dernière, il n'y a pas de consensus concernant la valeur de l'élasticité de substitution. Cette valeur dépend du niveau d'agrégation et, pour l'alimentaire, varie en moyenne entre 3,13 et 7,84, selon la méthode économétrique utilisée (Raimondi and Olper, 2009). Citons également Hertel et al. (2007) qui estiment les élasticités de substitution de tous les secteurs et obtiennent une moyenne simple de 7,0 (pour une agrégation à 5 chiffres et 40 groupes de marchandises). Nous prenons donc une valeur alignée sur celles utilisées dans la littérature,

13. Ce calcul est basé sur le fait que $\widehat{\psi_{it}} = Y^R_{it} \cdot \left(\Pi^R_{it}\right)^{\sigma-1}$ et $\widehat{\chi_{jt}} = E^R_{jt} \cdot \left(P^R_{jt}\right)^{\sigma-1}$.

14. En effet, le modèle ne converge pas pour les valeurs d'élasticité de substitution σ estimées. La plus petite valeur pour laquelle le modèle converge est $\sigma = 7$, et l'on obtient des résultats très similaires pour les valeurs $\sigma = 5$ et $\sigma = 9$ (quand c'est possible).

à savoir $\sigma = 7$. Cette valeur nous permet de parvenir à la convergence de l'équilibre général (détaillée dans la suite), pour tous les scénarios, ce qui n'est pas le cas pour des σ inférieurs. Afin de vérifier la robustesse de ce choix, nous reproduisons les estimations et simulations pour $\sigma = 5$ et $\sigma = 9$, et nous comparons les coefficients et les résultats avec ceux obtenus pour $\sigma = 7$. Nous discutons ce test et ces résultats dans la Section 5.1.

(2) Scénarios des futures politiques commerciales.
Il n'y a, à l'heure actuelle, aucune certitude quant aux débouchés des négociations des accords commerciaux entre le Royaume-Uni et ses partenaires. Ainsi, nous souhaitons simuler des cas extrêmes, ce qui permettra de donner des fourchettes d'impacts. Les accords commerciaux se traduisent par des augmentations ou des diminutions des différents coûts commerciaux. Nous définissons nos scénarios par des variations des coûts à l'échange entre le Royaume-Uni et ses partenaires, *i.e.* l'Union Européenne (incluant la France et la Bretagne) et le reste du monde. Nous proposons deux débouchés possibles pour les relations commerciales du Royaume-Uni avec les pays de l'Union Européenne, correspondant à des nouveaux niveaux de droits de douane et distances réglementaires de MNT: un accord de libre-échange proche du *status quo* ou un retour aux règles de l'Organisation Mondiale du Commerce (OMC), avec l'introduction des droits de douanes et des mesures non-tarifaires égaux à ceux imposés aux partenaires du régime de la nation la plus favorisée[15]. Pour chacun de ces cas, nous considérons également deux hypothèses sur les futures relations commerciales du Royaume-Uni avec les pays tiers: soit une réplication des accords actuels de l'Union Européenne, soit des accords commerciaux préférentiels avec les principaux partenaires extra-européens du Royaume-Uni et un retour aux règles de l'OMC pour le reste des pays. Un dernier scénario suppose une libéralisation totale et unilatérale du marché britannique, *i.e.* des droits de douane nuls sur les importations en provenance de tous les partenaires. Des nouveaux droits de douane d'importation prévisionnels, applicables dès le 1er janvier 2021, ont été annoncés par le Royaume-Uni le 19 mai 2020[16]. Il s'agit d'un "*UK Global Tariff*" ou UKGT, qui remplacera le "*Tarif Douanier Commun*" (TDC) et qui s'appliquera sur tous les produits d'importation du Royaume-Uni exportés par des pays avec lesquels il n'a pas d'accords commerciaux. Les droits de douane seront plus faibles que ceux actuellement en vigueur. L'objectif de ce UKGT est de faciliter les échanges commerciaux avec le Royaume-Uni en allégeant les charges administratives liées aux droits de douane. En particulier, tous les droits de douane inférieurs à 2% seront ramenés à zéro. Les changements sont de quatre types: libéralisation (droits de douane réduits à zéro), simplification (droits de douane arrondis vers le bas ou tronqués), réduction (abaissés par rapport aux droits de douane

15. Le régime de la nation la plus favorisée (MFN - Most Favored Nation) correspond au plus haut niveau de protection commerciale qu'un pays impose à ses partenaires commerciaux. Les partenaires avec lesquels le pays a négocié un accord commercial (une zone de libre échange, une union douanière ou un niveau plus élevé d'intégration économique) jouissent d'un meilleur niveau d'accès au marché, traduit par des droits de douane plus bas, voire nuls, et des mesures non-tarifaires similaires, voire identiques, à celles imposées aux producteurs domestiques.
16. https://www.gov.uk/government

actuels, mais au-delà de la simplification), conversion de devises (conversion des euros en GBP seulement). Bien que de nombreux droits de douane aient varié, ils concernent principalement le secteur non alimentaire, et les changements sont pour la plupart très faibles. En effet, le gouvernement britannique maintient des droits de douane sur un certain nombre de produits soutenant les industries britanniques telles que l'agriculture, l'automobile et la pêche. Comme évoqué au Chapitre II, l'UKGT entraînera l'absence de droits de douane sur 47% du nombre de produits importés au Royaume-Uni (contre 27% avec le TDC de l'Union Européenne), en cas d'absence d'accord commercial. Le Tableau 1 résume les cinq scénarios retenus. Chaque scénario correspond à un niveau hypothétique (contrefactuel) des coûts aux échanges τ_{ijt}^{CFL}. Le calcul de ces coûts contrefactuels est détaillé dans la Section 4.1 et le Tableau A2 dans les annexes. Les scénarios concernant le rétablissement total ou partiel des contrôles douaniers et des mesures non tarifaires entre la République d'Irlande et l'Irlande du Nord, ou entre l'Irlande du Nord et la Grande-Bretagne ne sont pas traités ici. Ainsi nous ne traitons pas la possibilité de la concurrence de pays tiers exportant des biens agro-alimentaires répondant à des normes sanitaires moins contraignantes vers l'Union Européenne *via* l'Irlande du Nord.

(3) Équilibre partiel.

Nous nous intéressons d'abord aux effets directs des changements en termes de politique commerciale, induits par le Brexit. En équilibre partiel, on estime les effets en supposant que les dépenses et les productions de chaque pays, E_{jt} et Y_{it}, restent inchangées. Chaque scénario introduit une évolution des coûts aux échanges bilatéraux, de τ_{ijt} à τ_{ijt}^{CFL}, qui implique une modifications des restitances multilatérales. Nous régressons les flux commerciaux observés sur les coûts aux échanges contrefactuels spécifiques à chaque scénario:

$$X_{ijt} = \left(\tau_{ijt}^{CFL}\right)^{1-\sigma} \cdot \psi_{it}^{PE} \cdot \chi_{jt}^{PE} \cdot \varepsilon_{ijt} \tag{6}$$

et utilisons les valeurs estimées des effets fixes exportateur-année et importateur-année, $\widehat{\psi_{it}^{PE}}$ et $\widehat{\chi_{jt}^{PE}}$, pour calculer les nouvelles valeurs des RML [17]. Par l'utilisation directe des coûts aux échanges contrefactuels τ_{ijt}^{CFL} dans l'équation (6), nous conservons inchangés les effets marginaux de toutes les composantes des coûts aux échanges [18]. Pour chaque scénario, le niveau des flux bilatéraux en équilibre partiel correspond alors à la valeur prédite par le modèle:

$$X_{ijt}^{PE} = \left(\tau_{ijt}^{CFL}\right)^{1-\sigma} \cdot \widehat{\psi_{it}^{PE}} \cdot \widehat{\chi_{jt}^{PE}} = \left(\tau_{ijt}^{CFL}\right)^{1-\sigma} \cdot Y_{it}^{R}\left(\Pi_{it}^{PE}\right)^{\sigma-1} \cdot E_{jt}^{R}\left(P_{jt}^{PE}\right)^{\sigma-1} \tag{7}$$

Nous pouvons ensuite calculer les valeurs contrefactuelles en équilibre partiel des variables du modèle correspondant à chaque scénario.

17. $\Pi_{it}^{PE} = \left(\widehat{\psi_{it}^{PE}}/Y_{it}^{R}\right)^{\frac{1}{\sigma-1}}$ et $P_{jt}^{PE} = \left(\widehat{\chi_{jt}^{PE}}/E_{jt}^{R}\right)^{\frac{1}{\sigma-1}}$.

18. Les paramètres β_1 à β_4 et δ^m utilisés dans le calcul des coûts aux échanges contrefactuels τ_{ijt}^{CFL} sont égaux à leur valeur initiale estimée sur les valeurs observées.

(4) Équilibre général.
Dans cette dernière étape nous calculons les effets indirects des différents scénarios de Brexit en intégrant les ajustements en termes de prix. En effet, il s'agit d'un équilibre général car on permet aux prix en sortie d'usine de répondre aux variations des RML elles mêmes induites par la variation des coûts à l'échange. Ainsi, le changement des coûts aux échanges entraîne une variation des RML, donc une variation des prix en sortie d'usine, qui modifient la valeurs des dépenses E_{jt} et revenus Y_{it}. Pour obtenir ces nouvelles valeurs de dépense et de production nous utilisons les valeurs des flux en équilibre partiel et imposons le respect des contraintes budgétaires et l'égalité de l'offre et de la demande. Nous recalculons les RML selon les équations (2) et (3), en utilisant les valeurs ajustées des dépenses et revenus et le niveau contrefactuel des coûts aux échanges. Les nouvelles valeurs des variables sont injectées dans l'équation (1) et la procédure est répétée jusqu'à convergence des prix sortie d'usine. Ces derniers s'ajustent en fonction des nouveaux coûts aux échanges jusqu'à ce que les contraintes d'équilibre du modèle soient respectées: les équations (1) à (3), plus les contraintes budgétaires et l'égalité de l'offre et de la demande (Yotov et al., 2016). Nous obtenons ainsi le niveau des flux commerciaux (internationaux et domestiques) qui prend en compte les effets indirects de la variation des coûts aux échanges sur toutes les variables du modèle:

$$X_{ijt}^{GE} = \left(\tau_{ijt}^{CFL}\right)^{1-\sigma} \cdot Y_{it}^{GE}\left(\Pi_{it}^{GE}\right)^{\sigma-1} \cdot E_{jt}^{GE}\left(P_{jt}^{GE}\right)^{\sigma-1} \tag{8}$$

Plus précisément, puisque tous les scénarios ne convergent pas pour certains groupes de produits, nous gardons, pour chacun des groupes, uniquement les variables statistiquement significatives [19] dans les estimations de la première étape (calcul des valeurs de référence). Cette restriction est nécessaire pour estimer les effets des cinq scénarios contrefactuels sur les variables du modèle.

On utilise la structure du modèle pour calculer les ajustements des pays au nouvel environnement commercial en termes d'indices de prix (résistances multilatérales), de production et de niveau de dépense. Enfin, nous entrons ces résultats dans le modèle et calculons le niveau final des flux commerciaux contrefactuels sous chaque scénario. L'évolution des flux commerciaux sous chaque scénario comparée aux flux observés permet de donner une idée de l'amplitude des effets du Brexit sur le commerce international, pour les produits agro-alimentaires. Nous appliquons cette stratégie pour chaque groupe de produits g. Pour la simplicité de l'exposé nous avons omis l'indice g indiquant le groupe de produits échangés.

19. Niveau alpha de significativité de 0,10.

Tableau 1: Scénarios proposés

		Accords commerciaux entre le RU et l'UE	
		(i) FTA type CETA+	(ii) Règles OMC
Accords commerciaux entre le RU et ses partenaires hors UE	(a) Réplication des accords de l'UE avec les pays tiers; règles de l'OMC avec les partenaires hors UE	FTA RU-UE et réplication des FTA de l'UE (S1)	RU "*forteresse*" (S2)
	(b) PTA avec les principaux partenaires hors UE ; règles de l'OMC avec le reste	FTA RU-UE FTA et PTA avec les principaux partenaires hors UE (S3)	PTA avec les principaux partenaires hors UE et règles OMC avec le reste (S4)
		Libéralisation totale du marché britannique (S5)	

Notes: FTA : Free Trade Agreement, PTA : Preferential Trade Agreement, CETA : Comprehensive Economic and Trade Agreement

4 Données internationales, françaises et bretonnes

4.1 Données observées

La base de données finale que nous utilisons dans le modèle est obtenue en combinant de nombreuses sources de données. Les données sur les flux commerciaux proviennent de la base BACI (Base pour l'Analyse du Commerce International) du CEPII (Centre d'Études Prospectives et d'Informations Internationales) au niveau SH6 (Système Harmonisé à 6 chiffres). Dans cette base nous sélectionnons les flux (importations et exportations, en euros) des 57 plus grands exportateurs et importateurs de produits alimentaires au cours de la période 2012-2015, couvrant 76% du commerce mondial dans ce secteur. Nous scindons la France en deux économies distinctes: la Bretagne et "*le reste de la France hors Bretagne*". Nous obtenons ainsi un panel de 58 partenaires commerciaux. Les données régionales relatives à la Bretagne sont présentées en Section 4. Le calcul des flux domestiques est également présenté dans la même section. Pour la totalité des partenaires, nous utilisons une structure de coûts commerciaux combinant les droits de douane, les mesures non tarifaires et les variables standards sur les liens bilatéraux entre les pays utilisées dans la littérature commerciale (distance géographique, frontière commune, langue commune,

passé colonial commun). Les données sur ces variables proviennent du CEPII [20]. Les données sur les mesures tarifaires et non tarifaires au niveau SH6 proviennent de la base de données TRAINS (Trade Analysis Information System) de UNCTAD (United Nations Conference on Trade and Development). Pour les mesures tarifaires nous utilisons les droits de douane appliqués qui prennent en compte les droits préférentiels (réduits ou nuls) conformes aux accords commerciaux combinant les droits *ad valorem* et l'équivalent *ad valorem* des droits spécifiques. Concernant les mesures non tarifaires, la base UNCTAD indique le nombre de MNT appliquées par le pays importateur sur le produit au niveau SH6, pour chaque type m de MNT. Si l'on prend cette mesure telle quelle dans notre modèle de gravité, on ne pourra séparer l'effet de cette variable (le nombre de MNT de type m) d'un autre effet spécifique à l'importateur. Pour contourner cela, nous répliquons la méthode de Cadot et al. (2018) reprise dans Cheptea et al. (2020) (*i.e.* le Chapitre II de la présente thèse) qui consiste à calculer des distances règlementaires pour chaque paire de pays, produit et type de MNT. Pour chaque type m, la distance règlementaire est la distance normalisée entre le nombre de MNT du même type sur un produit donné dans le pays exportateur et importateur. Les valeurs sont comprises entre 0 et 1. Une distance égale à 1 correspond au cas où les deux pays appliquent des types de MNT totalement différents, alors qu'une valeur de 0 indique que les pays appliquent exactement le même nombre de MNT du même type. Nous calculons cette distance pour chaque type de MNT pour les six catégories les plus fréquentes. La limite de cette approche est que deux mesures peuvent être du même type m mais correspondre à des contraintes différentes. Par exemple l'une des deux mesures peut fixer un seuil de pesticides très restrictif alors que pour l'autre le seuil fixé sera au contraire peu contraignant. Pourtant, ces deux mesures seront considérées dans notre calcul comme similaires.

Pour la distance géographique entre deux régions $dist_{ij}$ nous utilisons la distance à vol d'oiseau (cercle géodesique) entre les villes les plus peuplées (Rennes pour la Bretagne et Paris pour le reste de la France). Cette distance est calculée comme l'arc du grand cercle (la géodésique) à partir des données sur la latitude et la longitude des villes et en considérant la terre comme une sphère. De façon générale, on considère que les distances entre la Bretagne et le reste du monde sont identiques aux distances entre le reste de la France et le reste du monde. Nous différencions ces deux distances uniquement pour les plus proches voisins de la France et la Bretagne, à savoir: Allemagne, Suisse, Italie, Belgique, Royaume-Uni, Irlande. Les distances intra-nationales et intra-régionales sont calculées comme des distances internes selon Mayer and Zignago (2011) et dont la formule est détaillée en annexe.

Sur l'ensemble des mesures non tarifaires utilisées par les pays et répertoriées par l'UNCTAD (voir le Tableau A3 dans l'annexe), nous retenons seulement celles qui sont

20. Voir http://www.cepii.fr pour plus de détail concernant le calcul de la distance pondérée $distw$.

utilisées le plus souvent dans le commerce international des produits agricoles et alimentaires [21]. On remarque que l'utilisation des mesures sanitaires et phyto-sanitaires (SPS) coïncide souvent avec l'utilisation des mesures relevant de la catégorie obstacles techniques au commerce (OTC). Pour cette raison, les distances règlementaires correspondant à ces deux types de mesures non tarifaires sont fortement correlées. Dans ces conditions, l'utilisation concomitante de ces deux variables dans la même équation génère un biais de multicolinéarité, alors que l'omission d'une des deux engendre un biais de variable omise. Pour pallier cette difficulté, nous utilisons la moyenne des deux distances règlementaires, que nous notons $dist_MNT^{A\&B}$. Une autre catégorie importante de mesures non tarifaires dans le cas des produits du secteur agricole et alimentaire sont les contrôles et autres formalités avant expédition. La dernière catégorie de mesures non tarifaires que nous intégrons dans la spécification des coûts aux échanges sont les mesures qui agissent directement sur la quantité des produits importés (tels que les licences d'importation, les quotas, les restrictions à l'importation, etc.). Suivant les catégories des MNT utilisées par l'UNCTAD, nous notons $dist_MNT^{C}$ et $dist_MNT^{E}$ respectivement les distances règlementaires correspondant aux deux dernières catégories de MNT.

La spécification des coûts aux échanges (4) devient donc:

$$\begin{aligned}\tau_{ijt}^{1-\sigma} &= dist_{ij}^{\beta_1} \exp\left[contig_{ij}\right]^{\beta_2} \exp\left[langcom_{ij}\right]^{\beta_3} \exp\left[comcol_{ij}\right]^{\beta_4} \left(1+tariff_{ijt}\right)^{1-\sigma} \\ &\quad \exp\left[dist_MNT_{ijt}^{A\&B}\right]^{\delta_{A\&B}} \exp\left[dist_MNT_{ijt}^{C}\right]^{\delta_C} \exp\left[dist_MNT_{ijt}^{E}\right]^{\delta_E} \qquad (9)\end{aligned}$$

Nous obtenons les coûts aux échanges contrefactuels correspondants à chaque scénario en remplaçant dans l'équation (9) les droits de douanes et les distances règlementaires observées par leurs valeurs hypothétiques. Nous supposons que la signature d'accords commerciaux entre différents partenaires se traduit par une réduction des droits de douanes et des distances règlementaires des MNT qui prennent la forme de contrôles et autres formalités avant expédition (type C dans la nomenclature UNCTAD). De manière similaire, nous modélisons le retour aux règles de l'OMC par une hausse des droits de douanes et des distances règlementaires des MNT de type contrôles et autres formalités avant expédition (voir le Tableau A2 pour les détails). Les coûts contrefactuels aux échanges spécifiques à chaque scénario sont donc calculés selon l'équation suivante:

$$\begin{aligned}\left(\tau_{ijt}^{CFL}\right)^{1-\sigma} &= dist_{ij}^{\widehat{\beta}_1} \exp\left[contig_{ij}\right]^{\widehat{\beta}_2} \exp\left[langcom_{ij}\right]^{\widehat{\beta}_3} \exp\left[comcol_{ij}\right]^{\widehat{\beta}_4} \left(1+tariff_{ijt}^{CFL}\right)^{1-\sigma} \\ &\quad \exp\left[dist_MNT_{ijt}^{A\&B}\right]^{\widehat{\delta}_{A\&B}} \exp\left[\left(dist_MNT_{ijt}^{C}\right)^{CFL}\right]^{\widehat{\delta}_C} \exp\left[dist_MNT_{ijt}^{E}\right]^{\widehat{\delta}_E} (10)\end{aligned}$$

où l'exposant CFL indique le niveau contrefactuel des variables et les chapeaux indiquent les valeurs estimées des paramètres, obtenues par l'estimation de l'équation (5) séparement

21. Nous conservons les mêmes catégories que celles utilisées par Cheptea et al. (2020) et dans le Chapitre II de la présente thèse.

pour chaque groupe g de produits échangés.

Les données de douanes nous fournissent les importations et exportations bretonnes en nomenclature CPF4 [22], *i.e.* les exportations de la Bretagne vers le reste du monde (hors France) et les importations depuis le reste du monde (hors France) vers la Bretagne. Pour notre étude nous devons tout d'abord trouver un niveau d'agrégation compatible avec les données BACI et les données de douanes. Nous obtenons 16 groupes de produits. Le Tableau 2 présente les 16 groupes retenus et donne le poids de chaque groupe dans le commerce total (hors flux domestiques).

Tableau 2: Le commerce mondial en 2015 par groupe de produits

Catégorie	Valeur (milliards €)	Poids (%)
1. Animaux vivants et produits animaux	18,60	1,75
2. Autres boissons alcoolisées	45,37	4,28
3. Autres produits	20,59	1,94
4. Autres préparations	76,73	7,24
5. Autres préparations de fruits et légumes	49,20	4,64
6. Boissons non alcoolisées	15,23	1,44
7. Café, épices, cacao, sucre	100,92	9,52
8. Céréales et produits céréaliers	175,82	16,58
9. Fruits et légumes	126,37	11,92
10. Huile et graisses	94,66	8,93
11. Poisson et produits de la mer	97,62	9,21
12. Produits du travail du grain	12,92	1,22
13. Produits laitiers	56,86	5,36
14. Tabac	25,50	2,41
15. Viande et produits carnés	114,56	10,80
16. Vins	29,33	2,77
Total	1060,3	100

Notes: Calcul des auteures, hors flux domestiques, à partir de Comext

Il n'existe pas de données directes concernant les flux intra-nationaux (intra- et inter-régionaux). Or, nous avons besoin **(i)** des flux commerciaux entre la Bretagne et le reste de la France et **(ii)** des flux domestiques (intra-Bretagne, intra-reste de la France et intra de chacun des pays de la base). Il n'existe pas de base de données répertoriant les flux commerciaux au niveau régional. De plus, les données de production et de transformation qui pourraient permettre de les reconstituer ne sont pas publiques ou trop agrégées. Nous proposons ici de les prédire.

22. CPF: Classification de Produit Française, nomenclature officielle. Le CPF4 est un niveau intermédiaire de la CPF, gérée par l'INSEE, qui est une nomenclature de classification des produits et services échangés. Source: http://lekiosque.finances.gouv.fr

4.2 Prédiction des données manquantes

Pour construire les flux entre la Bretagne et le reste de la France et les flux intra-nationaux et intra-régionaux, nous reprenons l'équation de gravité (5). Nous apportons quelques adaptations à cette équation, détaillées ci-dessous, puis nous utilisons l'estimateur PPML (Pseudo Poisson Maximum Likelihood) pour nos estimations sur les flux existants. Le PPML est traditionnellement préféré aux moindres carrés ordinaires (MCO) dans le modèle de gravité, car il présente des avantages concernant l'hétéroscédasticité, la prise en compte des flux nuls et la cohérence des effets fixes avec les indices de RML. Nous utilisons ensuite les effets fixes pays-année ($\widehat{\psi_{it}}$ et $\widehat{\chi_{jt}}$) et les paramètres estimés $\widehat{\beta_1}$ à $\widehat{\beta_4}$ et $\widehat{\delta^m}$ pour reconstruire les flux manquants.

(i) Flux commerciaux entre la Bretagne et le reste de la France.
Pour la prédiction des flux intra- et inter-régionaux, nous repartons de l'équation (5). Cependant, nous utilisons, à la place de la distance à vol d'oiseau $dist_{ij}$, la distance pondérée $distw_{ij}$. Celle-ci nous permet de prendre en compte, pour le couple paire Bretagne - Reste de la France, non seulement la distance simple, mais aussi la population des villes les plus peuplées de la Bretagne et du reste de la France. Nous considérons que les distances pondérées entre la Bretagne et le reste du monde sont identiques aux distances entre le reste de la France et le reste du monde, pour tous les partenaires. La formule est détaillée en annexe. Ce changement nous amène à l'équation (11) ci-dessous:

$$\begin{aligned} X_{ijt} &= \exp[\ \beta_1\ \ln distw_{ij} + \beta_2\ contig_{ij} + \beta_3\ langcom_{ij} + \beta_4\ comcol_{ij} + (1-\sigma)\ln\left(1 + tariff_{ijt}\right) \\ &\quad + \delta_{A\&B}\ dist_MNT^{A\&B}_{ijt} + \delta_C\ dist_MNT^{C\ \ CFL}_{ijt} + \delta_E\ dist_MNT^{E}_{ijt}\ ]\cdot \psi_{it}\ \chi_{jt}\ \epsilon_{ijt} \end{aligned} \tag{11}$$

L'estimation des coefficients est réalisée sur les flux commerciaux des 58 partenaires. Bien que de nouvelles méthodes existent et permettent d'appliquer la gravité pour inférer les coûts commerciaux entre régions ou provinces (par exemple les provinces du Canada dans Agnosteva et al., 2019), ici nous reprenons simplement les coûts commerciaux classiques utilisés dans les modèles de gravité et nous les fixons comme suit, entre la Bretagne et la France: $contig_{ij}$=1, $langcom_{ij}$ = 1, c'est-à-dire présence d'une frontière commune et d'une langue commune entre la France et la Bretagne, $comcol_{ij}$ = 0 car pas de relation coloniale post-1945, $distw_{ij}$=522.81 km qui est la distance pondérée, $tariff_{ijt}$=0, $MNT^{A\&B}_{ijt}$=MNT^{C}_{ijt}=MNT^{E}_{ijt}=0. Les barrières tarifaires et non tarifaires sont supposées nulles entre la Bretagne et la France. Les détails sont présentés en annexe. Nous utilisons les coefficients et effets fixes estimés (par groupe de produit) pour calculer les flux pour les couples (i=Bretagne ; j=Reste de la France) et (i=Reste de la France ; j=Bretagne), pour chaque groupe de produits g:

$$\begin{aligned} X_{ijt} &= \exp[\ \widehat{\beta_1}\ \ln distw_{ij} + \widehat{\beta_2}\ contig_{ij} + \widehat{\beta_3}\ langcom_{ij} + \widehat{\beta_4}\ comcol_{ij} + (1-\sigma)\ln\left(1 + tariff_{ijt}\right) \\ &\quad + \widehat{\delta_{A\&B}}\ dist_MNT^{A\&B}_{ijt} + \widehat{\delta_C}\ \left(dist_MNT^{C}_{ijt}\right)^{CFL} + \widehat{\delta_E}\ dist_MNT^{E}_{ijt}\ ]\cdot \widehat{\psi_{it}}\ \widehat{\chi_{jt}} \end{aligned} \tag{12}$$

(ii) Flux commerciaux intra-nationaux et intra-régionaux.
On utilise la même méthode mais en prenant en compte l'ensemble des couples (58 partenaires). Les estimations nous permettent de calculer les flux commerciaux domestiques, *via* l'équation suivante:

$$X_{iit} = \exp\left[\widehat{\beta_1} \ln distw_{ii}\right] \cdot \widehat{\psi_{it}}\ \widehat{\chi_{it}} = distw_{ii}^{\widehat{\beta_1}} \cdot \widehat{\psi_{it}}\ \widehat{\chi_{it}} \tag{13}$$

où X_{iit} est la valeur des échanges domestiques pour chaque couple pays-année ou région-année $i \times t$, $\ln distw_{ii}$ – le logarithme de la distance intra-nationale ou intra-régionale pondérée [23], $\widehat{\beta_1}$ – l'élasticité estimée des flux commerciaux par rapport à cette distance, et $\widehat{\psi_{it}}$ et $\widehat{\chi_{it}}$ – les effets fixes exportateur-année et importateur-année estimés par l'équation (11). Les autres coûts aux échanges de l'équation (9) ne sont pas pris en compte car ils ne sont pas pertinents pour les flux domestiques. Les hypothèses du modèle, évoquées dans la Section 3.1, sont respectées.

(iii) Points de vigilance pour les données régionales.
Les données françaises régionales sont sujettes à d'importante limites. Leur exploitation doit en tenir compte. Signalons en particulier que les données de douanes régionales ne tiennent pas compte des lieux de fabrication mais d'exportation. Par exemple, si une usine de produits alimentaires en Bretagne exporte ses produits à travers le monde *via* le marché de Rungis ou l'aéroport Charles de Gaulle, les dédouanements se feront sur les lieux d'exportation et viendront incrémenter les statistiques dounanières d'Île-de-France, mais pas celles de Bretagne. Ainsi, des biens alimentaires fabriqués en Bretagne mais exportés depuis une autre région française seront pris en compte dans les données de production bretonne (données DRAAF [24]) mais pas dans les données de douanes bretonnes. Les données commerciales se basent ainsi sur le lieu d'exportation et pas de fabrication. Cela induit donc un biais: les exportations bretonnes peuvent être sur évaluées, mais plus probablement sous évaluées, en particulier au profit de l'Île-de-France. Cependant, à notre connaissance, il n'existe pas de base de données régionales commerciales alternative.

4.3 Résultats et robustesse des données reconstituées

Résultats pour la Bretagne et le reste de la France.
Le Tableau 3 reprend les 16 groupes retenus ainsi que les résultats de la prédiction des flux manquants relatifs à la Bretagne: inter-régional (Bretagne vers France) dans la colonne (1) et intra-régional dans la colonne (4). La colonne (2) correspond à la valeur exportée vers l'étranger par la Bretagne, donnée par les douanes régionales. La colonne (3) est la somme des colonnes (1) et (2) et représente les exportations totales de la Bretagne, y compris vers la France. Enfin, nous estimons la valeur produite par la Bretagne dans la colonne (5) qui

23. Voir http://www.cepii.fr pour de détail du calcul de cette distance intra-nationale ou intra-régionale.
24. Direction Régionale de l'Alimentation, de l'Agriculture et de la Forêt

est la somme des colonnes (3) et (4). Le Tableau 4 reproduit le Tableau 3 mais pour le reste de la France, à titre de comparaison. D'un point de vue méthodologique, la reconstitution des flux intra-nationaux (intra- et inter-régionaux) vient combler le manque de données au niveau régional et présente l'avantage de pouvoir être répliquée pour des études ultérieures et d'autres régions que la Bretagne. Cependant, il convient de soulever les limites de cette estimation, et les tests de robustesse effectués.

Tableau 3: Flux commerciaux et production agricole et alimentaire de la Bretagne par groupe de produits

Groupe de produits	Bretagne vers le reste de la France [estimé]	Bretagne vers l'étranger [douanes]	Exportations totales de la Bretagne	Conso domestique (flux intra Bretagne) [estimé]	Production bretonne
	(1)	(2)	(3)=(1)+(2)	(4)	(5)=(3)+(4)
1. Animaux viv. et prod. an.	41	128	169	10	178
2. Autres boissons alcoolisées	1	4	5	0	5
3. Autres produits	4	18	22	1	22
4. Autres préparations	141	491	632	12	645
5. Autres prép. fr. et lég.	31	96	128	4	132
6. Boissons non alcoolisées	3	9	11	0	11
7. Café, épices, cacao, sucre	8	25	33	0	34
8. Céréales et prod. cér.	64	280	344	16	360
9. Fruits et légumes	47	221	268	5	273
10. Huile et graisses	8	35	43	1	44
11. Poisson et prod. de la mer	64	245	309	13	322
12. Prod. du travail du grain	0	2	2	0	2
13. Produits laitiers	165	602	767	36	803
14. Tabac	0	0	0	0	0
15. Viande et produits carnés	560	1356	1916	36	1952
16. Vins	0	4	4	0	4
Total	1136	3517	4653	134	4787

Notes: Millions euros - 2015 - Sources : Douanes, BACI, calculs et prédictions des auteures

Caractérisation des flux prédits.

Nous vérifions tout d'abord que la condition de commerce équilibré est bien respectée [25], avant et après ajout des flux prédits à notre base. Au niveau mondial, on vérifie en particulier que $\sum_j E_{jtg} = \sum_i Y_{itg}$. Nous nous intéressons ensuite au ratio ϕ_{ig} pour chaque groupe et chaque pays i, suivant l'équation: $E_{itg} = \phi_{ig}.Y_{itg}$. Ainsi, ϕ_{ig} représente le ratio des achats sur le total des ventes. $\phi_{ig} = 1$ signifie que le pays i exporte autant de produits du groupe g qu'il en importe (en valeur). $\phi < 1$ signifie que le pays i exporte plus de produits du groupe g qu'il en importe (net exportateur). $\phi_{ig} > 1$ signifie que le pays i importe plus de produits

25. $\sum_i X_{ijtg} = \sum_j X_{ijtg}$

Tableau 4: Flux commerciaux et production agricole et agro-alimentaire de la France hors Bretagne par groupe de produits

Groupe de produits	France vers la Bretagne [estimé]	France vers l'étranger [douanes]	Exportations totales de la France	Conso domestique (flux intra France) [estimé]	Production française
	(1)	(2)	(3)=(1)+(2)	(4)	(5)=(3)+(4)
1. Animaux viv. et prod. an.	40	1907	1947	105	2052
2. Autres boissons alcoolisées	15	7046	7061	1214	8275
3. Autres produits	3	584	587	116	703
4. Autres préparations	83	5179	5262	560	5822
5. Autres prép. fr. et lég.	30	2249	2279	418	2696
6. Boissons non alcoolisées	5	1733	1738	162	1901
7. Café, épices, cacao, sucre	29	5252	5281	684	5966
8. Céréales et prod. cér.	168	11963	12131	1954	14085
9. Fruits et légumes	14	3803	3817	631	4448
10. Huile et graisses	31	1698	1729	142	1871
11. Poisson et prod. de la mer	44	1584	1627	210	1837
12. Prod. du travail du grain	23	1589	1611	135	1746
13. Produits laitiers	205	6881	7086	825	7910
14. Tabac	0	505	505	131	636
15. Viande et produits carnés	68	3078	3146	335	3481
16. Vins	6	9960	9966	664	10630
Total	763	65010	65773	8285	74058

Notes: Millions euros - 2015 - Sources : Douanes, BACI, calculs et prédictions des auteures

du groupe g qu'il en exporte (net importateur). Nous calculons ϕ_{ig} avant et après ajout des flux prédits, et nous nous intéressons à l'évolution de cette valeur. Le Tableau A4 en annexe présente les valeurs de ϕ_{ig} pour la Bretagne, pour chaque groupe de produits. La première colonne ne tient compte que des flux internationaux. On remarque que la Bretagne est nette exportatrice pour les groupes des animaux vivants, des autres préparations, des boissons non alcoolisées, des fruits et légumes, des produits laitiers et de la viande et produits carnés. Elle est nette importatrice pour les groupes des autres boissons alcoolisées, des autres produits, des autres préparations de fruits et légumes, du café, épices, cacao, sucre, des céréales et produits céréaliers, de l'huile et graisses, du poisson et produits de la mer, des produits du travail du grain, du tabac et des vins. C'est surtout les groupes de la viande et des animaux vivants qui se détachent, pour la partie exportation, avec un ϕ_{ig} très bas, et les groupes du tabac et des produits du travail du grain pour la partie importation, avec un ϕ_{ig} particulièrement élevé.

Lorsque l'on ajoute les flux entre la Bretagne et la France (dans la deuxième colonne) on remarque que le rapport des importations sur exportations augmente pour certains groupes, par exemple pour le groupe de boissons alcoolisées, pour lequel la Bretagne est nette importatrice. Cela signifie que la proportion de boissons alcoolisées importées (France vers

Bretagne) par rapport à celles exportées (Bretagne vers France) est plus forte que celle de la Bretagne avec le reste du monde. La Bretagne importe plus d'alcools (en valeur) du reste de la France, tels que le Cognac ou le Calvados, qu'elle n'en exporte (par exemple le cidre). Le rapport des importations sur exportations augmente également pour le groupe des produits laitiers, où la Bretagne est nette exportatrice. La Bretagne importe plus de produits laitiers (en valeur) du reste de la France, tels que les fromages, qu'elle n'en exporte (par exemple le beurre salé). Rappelons en effet que, pour des raisons historiques, la Bretagne produit peu voire pas de fromage. Elle produit en revanche beaucoup de beurre salé. Inversement, on remarque que le rapport des importations sur exportations diminue pour certains groupes, par exemple pour le groupe des fruits et légumes. La Bretagne exporte plus de fruits et légumes vers le reste de la France qu'elle n'en importe.

Robustesse et limites de la méthode: comparaisons.
Afin de vérifier la pertinence des valeurs intra- et inter-régionales obtenues, nous pouvons comparer la valeur produite ainsi prédite avec les chiffres d'affaires (CA) des différents groupes d'IAA fournis par la DRAAF et présentés dans le Tableau A1 en annexe. Cependant, **(i)** dans ce tableau les groupes de produits sont différents des nôtres: ils ne concernent que les IAA, et excluent donc l'activité agricole. Pour information, le CA de la production agricole était de 8,6 milliards d'euros en 2018 [26]. De plus, **(ii)** ce CA ne constitue qu'une approximation limitée de la valeur de la production. En effet, le CA prend en compte non seulement les activités agro-alimentaires, mais aussi les activités non agro-alimentaires des entreprises agro-alimentaires, tel que le transport par exemple. Par ailleurs, le CA des IAA bretonnes est celui des unités légales mono ou quasi mono régionales bretonnes, c'est-à-dire celles qui ont 80% ou plus de leurs effectifs dans la région Bretagne, et dont l'activité principale relève des IAA hors artisanat commercial (boucheries, charcuteries, boulangeries pâtisseries). Enfin, le CA est une notion propre à l'entreprise et non à l'établissement. Donc le CA d'une entreprise correspond à l'activité de l'ensemble de ses sites, y compris ceux implantés hors Bretagne. Pour ces raisons, le chiffre d'affaires fourni par la DRAAF (19 534 millions €) est bien supérieur à la production que l'on a estimée (4 787 millions €). Il couvre en effet un périmètre différent de la production alimentaire.

Une deuxième piste pour la validation de nos estimations consiste à comparer les valeurs estimées aux flux de marchandises de la base SitraM [27] du Ministère de la Transition écologique et solidaire, chargé des Transports. Cette base répertorie les flux nationaux de marchandises, entre départements et intra-départements. Elle nous permet de comparer les ratios entre nos estimations des flux intra-régionaux (France et Bretagne), celles des flux inter-régionaux (Bretagne vers le reste de la France et reste de la France vers la Bretagne). Là encore il existe plusieurs limites, par exemple seuls sont compris dans ces chiffres les échanges de marchandises de plus de 1000 kg ou d'une valeur supérieure à 1000 euros,

26. http://www.bretagne.synagri.com
27. https://www.statistiques.developpement-durable.gouv.fr

ainsi que les camions de plus de 3,5 tonnes [28].

Outre ces deux pistes, il n'existe pas de données nous permettant de vérifier la pertinence des valeurs de façon précise. Tenant compte de ces limites, les comparaisons suggèrent tout de même une probable sous-estimation de la consommation domestique (au niveau régional mais aussi national). En effet, les taux d'exportation des IAA (CA à l'étranger/CA total) sont généralement plus faibles que ceux auxquels on aboutit. Les taux d'exportation dans le secteur des IAA se situent entre 10 et 20%, en fonction des secteurs (selon l'ANIA [29]), alors qu'avec nos estimations les pays exportent plus que ce qu'ils consomment à l'intérieur du pays. Notons que les taux d'exportation de l'ANIA ne couvrent pas le secteur agricole. Nous utilisons dans la suite l'effet frontière pour confirmer cette hypothèse et, le cas échéant, faire les corrections nécessaires.

4.4 Correction des données reconstituées avec l'effet frontière

Afin de confirmer ou infirmer cette potentielle sous-estimation, nous mesurons l'effet frontière [30] et le confrontons à celui estimé dans la littérature. Le modèle de gravité est largement utilisé avec des flux et coûts à l'échange internationaux. En revanche, quand on l'applique aux flux domestiques, il semble que les coûts soient sur-estimés, et ainsi les flux domestiques sous-estimés. Ainsi, il semble que notre méthode ne nous permette pas d'estimer la vraie valeur des flux domestiques. La littérature liée à l'effet frontière traite cette comparaison des coûts domestiques et coûts internationaux. Olper and Raimondi (2008b) utilisent un modèle de type compétition monopolistique. Leurs données couvrent l'Union Européenne, les États-Unis, le Canada et le Japon. Ils estiment, pour le groupe des aliments transformés intra-UE, une valeur de 19,30 ($= \exp(2,96)$) [31], avec le commerce de chaque groupe de pays comme poids. Olper and Raimondi (2008a) utilisent un modèle de type gravité structurelle pour estimer l'effet frontière dans le commerce alimentaire parmi les pays "*QUAD*" *i.e.* l'UE, les États-Unis, le Canada et le Japon. Ils estiment un effet frontière moyen du QUAD de 30,57 ($= \exp(3,42)$), toujours avec le commerce de chaque groupe de pays comme poids. Anderson and Van Wincoop (2003) estiment un effet de 10,7 pour le Canada et 2,24 pour les États-Unis. Anderson and Yotov (2010) estiment un effet de 3,08 ($= \exp(1,124)$) pour l'agricole et 7,52 ($= \exp(2,017)$) pour l'alimentaire.

28. https://www.statistiques.developpement-durable.gouv.fr
29. Association Nationale des Industries Alimentaires: https://www.ania.net
30. L'effet frontière, ou "*border effect*" mesure dans quelle proportion le volume du commerce intérieur dépasse le volume du commerce international. Dans la littérature il peut être mesuré par différentes méthodes et avec différents estimateurs (ex: OLS, PPML).
31. Cela signifie que les échanges domestiques sont 19,30 fois plus élevés que ceux entre deux pays : $19,30 = \exp(2,96)$, avec 2,96 le coefficient associé à une variable dummy "*domestique*" dans une équation de gravité.

Nous estimons un effet frontière de 6,3 (= exp(1,8368)) au niveau agrégé [32] avec la méthode d'Olper and Raimondi (2008a). Cette valeur est plus faible que celle généralement estimée dans la littérature. Cela confirme que nos flux intra- et inter-régionaux prédits sont sous-estimés. Nous multiplions les flux domestiques (intra- et inter-régionaux) par un facteur de 4,87 (= exp(1,5832) = exp(3,42 − 1,8368)) pour arriver à un effet frontière de 30,57 (= exp(3,42)). Cette valeur correspond à celle estimée par Olper and Raimondi (2008a) pour les pays du QUAD. La condition d'égalité entre la somme des ressources et la somme des dépenses est toujours vérifiée, pour chaque groupe de produits. Les résultats sont présentés dans les Tableaux A5 et A6 en annexe. Avec ces flux corrigés on obtient une production alimentaire bretonne de 10,22 milliards d'euros, ce qui est plus proche de la valeur 19,5 milliards de CA des IAA fournie par la DRAAF. Pour le reste de la France on trouve 141,2 milliards d'euros.

Nous souhaitons vérifier que la modification des flux domestiques n'affecte pas ou peu les coefficients estimés de l'équation (5). Pour cela, nous ajoutons une dummy *"domestique"*, croisée avec les flux intra- et inter-régionaux. Nous obtenons ainsi l'équation (14).

$$\begin{aligned} X_{ijt} &= domestique_{ij}^{\alpha}\, dist_{ij}^{\beta_1} \exp\left(contig_{ij}\right)^{\beta_2} \exp\left(langcom_{ij}\right)^{\beta_3} \exp\left(comcol_{ij}\right)^{\beta_4} \\ &\quad \left(1 + tariff_{ijt}\right)^{1-\sigma} \cdot \prod_m \exp\left[dist_MNT_{ijt}^{m}\right]^{\delta_m} \cdot \psi_{it}\, \chi_{jt}\, \epsilon_{ijt} \end{aligned} \tag{14}$$

Avec $domestique_{ij} = 1$ si $i = j$ (intra-régional) ou si i et j correspondent à la France et au reste de la Bretagne (inter-régional). Nous estimons les coefficients de l'équation (14) sur tous les flux (internationaux, inter- et intra-régionaux), avec les flux prédits mais non corrigés d'une part, et avec les flux prédits et corrigés d'autre part. Nous observons peu de variation. En ajoutant cette dummy, on ajoute mécaniquement une contrainte de plus pour l'équilibre général: l'effet frontière reste inchangé dans tous les scénarios, *i.e.* quand les conditions sur les marchés internationaux changent, les exportateurs réorientent leur production vers d'autres marchés, mais pas vers le marché domestique.

Cependant, si nous corrigeons les flux domestiques, la convergence n'est pas atteinte pour la plupart des combinaisons de groupes et scénarios. Nous faisons le choix de réaliser les simulations sur les flux non corrigés, *i.e.* ceux correspondant aux Tableaux 3 et 4, en fixant un $\sigma = 7$. **(i)** Les coefficients estimés varient peu avec et sans correction des flux domestiques. La dummy atténue l'effet de la valeur des flux domestiques sur les autres coefficients. Pour nous assurer que la différence sur les résultats finaux est mineure, nous comparons les résultats (variation du commerce) avec et sans correction des flux, pour les combinaisons de flux corrigés qui convergent. Nous y revenons dans la section suivante. **(ii)** Nous souhaitons

32. Cela signifie que les échanges domestiques sont 6,3 fois supérieurs à ceux entre deux pays : 6,3 = exp(1,8368), avec 1,8368 le coefficient associé à une variable dummy *"domestique"* dans une équation de gravité.

également nous assurer que le choix du σ influence peu les résultats. Les Tableaux A7, A8, A9, A10, A11, A12, A13 et A14 en annexe présentent les estimations avec la base non corrigée et l'estimateur PPML des paramètres de gravité pour les 16 groupes et les 58 partenaires commerciaux retenus. Pour chacun des groupes, la colonne (a) tient compte de toutes les variables sans correction de σ, la colonne (b) fixe σ à 5, la colonne (c) fixe σ à 7 et la colonne (c) fixe σ à 9. Les coefficients associé à ln(*tariff*) sont donc, pour (b) (c) et (d), respectivement de -4, -6 et -8. Dans l'ensemble, les coefficients estimés conservent leur significativité et leur signe sous les différents σ, avec quelques exceptions, principalement lorsque l'on passe de $\sigma = 7$ à $\sigma = 9$ (par exemple pour les autres préparations, les MNT A&B deviennent significatives; pour les produits du travail du grain, les MNT C deviennent significatives). Quelques changements sont à noter aussi lorsque l'on passe de $\sigma = 5$ à $\sigma = 7$ (par exemple une perte de significativité de la variable $langcom_{ij}$ pour le groupe des produits de la mer).

5 La vulnérabilité de la Bretagne face au Brexit

5.1 Estimation du modèle de gravité

Sélection des variables significatives.

Comme évoqué précédemment, nous ne gardons que les variables statistiquement significatives pour les simulations, afin d'assurer la convergence pour tous les scénarios. Les Tableaux A15, A16, A17, A18, A19, A20, A21 et A22 présentent les estimations sur tous les flux (avec des flux domestiques non corrigés). Pour chacun des groupes, la colonne (a) tient compte de toutes les variables, même les non significatives, la colonne (b) ne tient compte que des variables significatives, et la colonne (c) est identique à la colonne (b), avec un σ fixé à 7. Donc, pour cette dernière, le coefficient associé à ln(*tariff*) est -6. Ainsi, si le *tariff* est non significatif, les colonnes (b) et (c) sont équivalentes. Les variables non significatives ne sont pas prises en compte dans le modèle pour les simulations des équilibres partiel et général. Cela implique que pour les groupes ayant un *tariff* non significatif, cette variable n'étant pas prise en compte dans les simulations, nous ne fixons pas $\sigma = 7$. Cette sélection de variables nous permet entre autres de choisir un σ plus bas par rapport à la situation où l'on prendrait en compte toutes les variables. Une exception est faite pour le groupe de la viande (groupe 15), pour lequel les scénarios S4 et S5 n'atteignent pas la convergence avec $\sigma = 7$. Pour le scénario S4, le σ est fixé à 9 et pour le scénario S5 le σ est fixé à 10. En dessous de ces valeurs, la convergence n'est pas atteinte. Il convient donc d'interpréter les résultats liés à ce groupe avec prudence.

Analyse des coefficients estimés.

Pour la majorité des groupes, les effets des variables de gravité traditionnelles sont conformes à ceux de la littérature empirique en commerce. Le commerce bilatéral décroît avec la distance et les droits de douanes et croît si les pays partagent une frontière commune, une langue ou un passé colonial. Pour quelques groupes, certaines de ces variables sont non

significatives. Enfin, nous observons des effets contraires à ceux attendus pour le groupe des autres préparations (pour la variable du passé colonial), et celui du tabac (pour la variable de contiguïté). Par ailleurs, on observe une grande diversité entre les groupes pour le coefficient de ln(*tariff*): il varie de -1.339 pour la viande à -6.662 pour les autres préparations de fruits et légumes (si l'on considère seulement les colonnes (a)). Nous notons des coefficients positifs mais non significatifs pour les autres boissons alcoolisées (0.036), les huiles (0.691) et les produits de la mer (0.808). Des mesures non tarifaires (MNT) de pré-expédition et de contrôle des quantités très différentes dans les deux pays partenaires (distance règlementaire élevée pour les MNT C et E) entravent généralement le commerce (sauf pour le tabac et les vins). L'effet estimé des écarts entre les normes SPS et les OTC (MNT A&B) dépend des groupes de produits, mais il entrave généralement le commerce. Pour certains groupes, cette distance favorise le commerce. Cela indique que, pour notre échantillon, l'aspect informationnel des SPS et des OTC améliore le commerce et l'emporte sur la perception en tant qu'obstacles au commerce. De façon générale, les effets de catalyseur ou de barrière au commerce des MNT peuvent varier en fonction du type de MNT, des proxys utilisés, et du niveau d'agrégation (Santeramo and Lamonaca, 2019).

5.2 Simulation des scénarios

Nous utilisons ces estimations ainsi que la méthodologie détaillée précédemment pour estimer les effets d'un changement des coûts aux échanges dans le cadre du Brexit, avec un modèle de gravité. Plus précisément, nous utilisons les coefficients estimés avec σ fixé à 7 [33]. Parmi notre échantillon de 58 partenaires nous nous focalisons sur les impacts pour les exports bretons, en termes de variation de la valeur des exportations. Avec les résultats des simulations nous pouvons identifier les groupes de produits les plus vulnérables face au Brexit pour la Bretagne et quantifier les pertes de parts de marché sous chaque scénario.

Remarques préliminaires

- Les scénarios font varier les niveaux de *tariff* et la distance règlementaire MNT C. Cela signifie que les groupes pour lesquels le *tariff* et/ou la distance règlementaire MNT C ne sont pas significatifs seront peu voire pas impactés.
- En particulier, il est possible que la variation soit la même d'un scénario à l'autre, si les variables clés sont non significatives.
- Pour certains groupes (autres préparations et tabac), les variables de *tariff* ou de distance règlementaire MNT C ont un effet positif sur le commerce, ce qui peut amener à des résultats contre-intuitifs .

33. A l'exception de la viande: nous utilisons $\sigma = 9$ pour le scénario S4 et $\sigma = 10$ pour le scénario S5.

5.2.1 Des pertes significatives sur les catégories alimentaires phares

Le Tableau 5 présente les variations de la valeur des exportations de la Bretagne vers le Royaume-Uni, en pourcentage, pour chaque scénario. En annexe, le Tableau A23 présente les variations des exportations du reste de la France vers le Royaume-Uni, et le Tableau A24 présente les variations des exportations de la Bretagne, tous destinataires confondus.

Les résultats pour la Bretagne et le reste de la France sont très proches, en termes de pourcentage de variation. En revanche, les volumes (ou valeurs) en jeu sont très différents. Le Tableau 6 donne la variation des exportations bretonnes vers le Royaume-Uni en valeur (millions d'euros). On remarque qu'en termes de valeur, les pertes les plus fortes sont occasionnées pour le groupe de la viande et produits carnés, pour les scénarios S4 et S5 (respectivement -56,87 millions € et -61,19 millions €) mais rappelons que ces deux derniers ont été obtenus avec des σ supérieurs et que, par conséquent, les effets peuvent être amplifiés. En écartant ces deux cas, les pertes les plus significatives se font, en pourcentage, sur les scénarios S2, S4 et S5. La viande est particulièrement impactée sous le scénario S2 (-31,47 millions €). La viande est le premier groupe de produits exportés par la Bretagne vers le Royaume-Uni, ce n'est donc pas surprenant qu'il soit si fortement impacté. Sont fortement touchées sous le scénario S2, mais dans une moindre mesure, les catégories des fruits et légumes (-8,20 millions €), des autres produits (-1,26 millions €) et des produits laitiers (-5,01 millions €).

Si l'on compare la France et la Bretagne en termes de variations en pourcentage des exportations vers le Royaume-Uni, la variation (gains) pour le vin est quasiment identique pour la France et la Bretagne (entre +2,80% et +3,53% selon les Tableaux 5 pour la Bretagne et A23 pour la France). En revanche, la valeur actuellement exportée par la Bretagne étant bien plus faible que celle exportée par le reste de la France, l'impact en valeur pour la Bretagne sera bien moins important que pour le reste de la France (seulement +0,01 millions € ou moins, selon les scénarios, pour la Bretagne, d'après le Tableau 6). Inversement, suivant le même raisonnement, pour la catégorie de la viande ou des céréales l'impact sera négatif et plus important pour la Bretagne, en valeur.

Concernant les variations pour la Bretagne uniquement, on observe que certains groupes sont peu sensibles au changement de scénarios, par exemple les autres boissons alcoolisées (autour de -0,06 millions €), les céréales et produits céréaliers (entre -1,93 et -2,09 millions €), et les huiles et graisses (entre -0,19 et -0,28 millions €).

Nous attendons donc des pertes particulièrement élevées pour les produits phares des exportations bretonnes, tels que les produits à base de viande, les fruits, les légumes, les produits laitiers, et dans une moindre mesure, les produits de la mer et les céréales. Notons que les groupes des autres produits et autres préparations sont des groupes extrêmement

hétérogènes et qui représentent un intérêt d'analyse moindre. Nous ne les commentons pas.

5.2.2 Compétitivité de la Bretagne et reports

La concurrence accrue avec les pays tiers sur le marché britannique aura des conséquences sur le marché européen. D'un côté, les producteurs bretons, français et européens seront pénalisés proportionnellement à leurs liens avec le marché britannique, et pourraient réorienter le surplus de production qui ne pourra plus être exportée au Royaume-Uni vers le marché intra-européen, entraînant potentiellement une baisse des prix (détournement de commerce). D'un autre côté, les producteurs bretons pourraient aussi accéder à des nouveaux débouchés vers le reste de l'Union Européenne (création de commerce).

Pour deux des catégories clés des exportations bretonnes qui sont les viandes et les céréales, les principaux concurrents de la Bretagne sur le marché britannique sont présentés dans les figures A9 et A10 en annexe. Pour la viande, les gros fournisseurs du Royaume-Uni sont l'Irlande, les Pays-Bas et l'Allemagne. Pour les céréales il s'agit surtout de la France et l'Allemagne. Ces concurrents pourraient réorienter leur surplus vers les autres pays européens.

Le Tableau 7 présente les variations de la Bretagne vers le reste de l'Union Européenne (hors France). Les variations sont globalement à la hausse, sauf pour quelques groupes: sous tous les scénarios, les vins subissent des impacts négatifs; et seulement sous certains scénarios pour les animaux vivants, les autres produits, les autres préparations, les autres préparations de fruits et légumes, les fruits et légumes, les produits laitiers et la viande. On remarque une forte augmentation pour les boissons non alcoolisées (jusqu'à +4,06%) et les autres boissons alcoolisées (jusqu'à +3,20%). Le tabac connaît également une forte hausse, mais il représente un volume très faible. Le scénario S2 est celui qui semble offrir le plus de possibilités de report au sein de l'Union Européenne, mais c'est aussi celui qui engendre le plus de pertes dans les exportations vers le Royaume-Uni et vers tous les destinataires en moyenne. Ces reports partiels pourraient atténuer l'impact négatif du Brexit sur le secteur alimentaire breton.

5.2.3 Robustesse des choix

La valeur de l'élasticité de substitution

Nous souhaitons vérifier la robustesse du choix du σ sur les résultats obtenus. Dans le Tableau 8 nous présentons les résultats des simulations menées avec $\sigma = 5$ (pour les groupes qui convergent pour cette valeur), et nous les comparons à ceux du Tableau 5, *i.e.* pour $\sigma = 7$. Le signe des résultats n'est pas affecté. Les variations atteignent jusqu'à près de 13 points de pourcentage, pour le tabac, mais hors tabac la moyenne simple est autour de 2,7 et les plus gros écarts correspondent aux scénarios S2 et S4.

La correction des flux intra-nationaux

Le Tableau 9 reprend le Tableau 5 mais avec les flux corrigés, et uniquement pour les groupes qui atteignent la convergence. Nous comparons les flux prédits non corrigés et corrigés. Les variations atteignent jusqu'à près de 10 points de pourcentage, pour le tabac, mais hors tabac la moyenne simple est autour de 1,7.

Tableau 5: Évolution des exportations de la Bretagne vers le RU, en %, avec $\sigma = 7$

Catégorie	S1	S2	S3	S4	S5
1. Animaux vivants et produits animaux	3,89	-33,82	4,80	-32,86	-16,93
2. Autres boissons alcoolisées	-16,30	-16,30	-16,71	-16,71	-16,30
3. Autres produits	-3,48	-21,01	-1,53	-17,73	-9,40
4. Autres préparations	3,78	-26,15	1,79	-29,17	-17,90
5. Autres préparations de fruits et légumes	0,00	-32,90	4,61	-27,64	-21,70
6. Boissons non alcoolisées	-2,60	-24,83	-1,94	-24,66	-12,55
7. Café, épices, cacao, sucre	0,00	-40,91	7,08	-33,97	-23,61
8. Céréales et produits céréaliers	-2,40	-2,40	-2,59	-2,59	-2,40
9. Fruits et légumes	0,00	-35,22	4,18	-30,43	-24,09
10. Huile et graisses	-10,71	-10,71	-7,56	-7,56	-10,71
11. Poisson et produits de la mer	-4,08	-4,08	-6,63	-6,63	-4,08
12. Produits du travail du grain	0,00	-20,72	-10,51	-37,10	-38,84
13. Produits laitiers	0,00	-18,46	1,74	-19,05	-20,83
14. Tabac	32,69	0,96	33,18	1,08	5,69
15. Viande et produits carnés	-1,67	-29,40	-17,89	-53,13	-57,17
16. Vins	2,80	2,80	3,53	3,53	2,80

Notes: Calcul par les auteures selon la procédure expliquée dans la section 3.2 en fixant $\sigma = 7$ (sauf pour le groupe de la viande)

Tableau 6: Évolution des exportations de la Bretagne vers le RU, en millions €, avec $\sigma = 7$

Catégorie	S1	S2	S3	S4	S5
1. Animaux vivants et produits animaux	0,26	-2,27	0,32	-2,20	-1,14
2. Autres boissons alcoolisées	-0,06	-0,06	-0,06	-0,06	-0,06
3. Autres produits	-1,26	-7,64	-0,56	-6,45	-3,42
4. Autres préparations	0,81	-5,63	0,39	-6,28	-3,85
5. Autres préparations de fruits et légumes	0,00	-0,78	0,11	-0,65	-0,51
6. Boissons non alcoolisées	-0,02	-0,17	-0,01	-0,17	-0,09
7. Café, épices, cacao, sucre	0,00	-0,44	0,08	-0,36	-0,25
8. Céréales et produits céréaliers	-1,93	-1,93	-2,09	-2,09	-1,93
9. Fruits et légumes	0,00	-8,20	0,97	-7,09	-5,61
10. Huile et graisses	-0,28	-0,28	-0,19	-0,19	-0,28
11. Poisson et produits de la mer	-0,66	-0,66	-1,07	-1,07	-0,66
12. Produits du travail du grain	0,00	-0,05	-0,02	-0,08	-0,09
13. Produits laitiers	0,00	-5,01	0,47	-5,17	-5,65
14. Tabac	0,00	0,00	0,00	0,00	0,00
15. Viande et produits carnés	-1,79	-31,47	-19,15	-56,87	-61,19
16. Vins	0,00	0,00	0,01	0,01	0,00

Notes: Calcul par les auteures selon la procédure expliquée dans la section 3.2 en fixant $\sigma = 7$ (sauf pour le groupe de la viande)

Tableau 7: Évolution des exportations de la Bretagne vers l'UE (hors France), en %, avec $\sigma = 7$

Catégorie	S1	S2	S3	S4	S5
1. Animaux vivants et produits animaux	-0,33	2,02	-0,16	2,18	1,75
2. Autres boissons alcoolisées	3,20	3,20	3,16	3,16	3,20
3. Autres produits	-0,04	-0,77	-0,05	-0,84	0,93
4. Autres préparations	-0,41	1,35	0,04	1,52	1,42
5. Autres préparations de fruits et légumes	0,00	2,19	-0,22	1,85	2,74
6. Boissons non alcoolisées	0,54	3,63	0,71	4,06	2,99
7. Café, épices, cacao, sucre	0,00	3,08	0,30	3,52	2,97
8. Céréales et produits céréaliers	0,21	0,21	0,22	0,22	0,21
9. Fruits et légumes	0,00	2,30	-0,56	1,85	0,66
10. Huile et graisses	0,28	0,28	0,20	0,20	0,28
11. Poisson et produits de la mer	0,35	0,35	0,57	0,57	0,35
12. Produits du travail du grain	0,00	1,61	0,29	1,63	1,80
13. Produits laitiers	0,00	1,27	1,74	2,19	-1,21
14. Tabac	25,12	25,83	25,94	26,72	25,65
15. Viande et produits carnés	0,10	-0,83	-2,60	-0,89	-3,12
16. Vins	-0,62	-0,62	-0,72	-0,72	-0,62

Notes: Calcul par les auteures selon la procédure expliquée dans la section 3.2 en fixant $\sigma = 7$ (sauf pour le groupe de la viande)

Tableau 8: Évolution des exportations de la Bretagne vers le RU, en %, avec $\sigma = 5$

Catégorie	S1	S2	S3	S4	S5
1. Animaux vivants et produits animaux	4,23	-22,07	4,96	-21,19	-11,09
3. Autres produits	-3,82	-15,56	-2,58	-13,92	-8,60
4. Autres préparations	4,03	-16,90	2,80	-18,67	-11,79
5. Autres préparations de fruits et légumes	0,00	-23,09	3,67	-19,09	-15,57
7. Café, épices, cacao, sucre	0,00	-28,55	5,73	-23,81	-18,51
8. Céréales et produits céréaliers	-2,52	-2,52	-2,70	-2,70	-2,52
10. Huile et graisses	-11,40	-11,40	-8,17	-8,17	-11,40
11. Poisson et produits de la mer	-4,38	-4,38	-6,69	-6,69	-4,38
12. Produits du travail du grain	0,00	-15,12	-7,78	-25,39	-28,25
14. Tabac	20,59	0,24	20,73	0,11	2,35
16. Vins	2,92	2,92	3,91	3,91	2,92

Notes: Calcul par les auteures selon la procédure expliquée dans la section 3.2 en fixant $\sigma = 5$

Tableau 9: Évolution des exportations de la Bretagne vers le RU, en %, avec des flux domestiques corrigés, avec $\sigma = 7$

Catégorie	S1	S2	S3	S4	S5
2. Autres boissons alcoolisées	-21,80	-21,80	-22,58	-22,58	-21,80
4. Autres préparations	4,84	-31,01	3,65	-33,93	-19,43
7. Café, épices, cacao, sucre	0,00	-45,83	7,22	-39,16	-27,07
8. Céréales et produits céréaliers	-3,11	-3,11	-3,24	-3,24	-3,11
10. Huile et graisses	-12,12	-12,12	-8,95	-8,95	-12,12
11. Poisson et produits de la mer	-5,00	-5,00	-6,54	-6,54	-5,00
14. Tabac	40,36	-7,90	42,30	-5,83	7,48
16. Vins	3,15	3,15	3,94	3,94	3,15

Notes: Calcul par les auteures selon la procédure expliquée dans la section 3.2 en fixant $\sigma = 7$

6 Discussion et conclusion

Le secteur alimentaire breton est résolument tourné vers le commerce extérieur. Le Royaume-Uni représente une destination d'importance majeure pour la Bretagne. Définir et quantifier les risques potentiels liés au Brexit et les défis associés est donc crucial pour cette région. En particulier, l'accroissement de la concurrence avec les autres fournisseurs du Royaume-Uni représente un risque majeur à ne pas sous-estimer. Les résultats pourront servir de piste pour guider les entreprises bretonnes dans le flou économique et commercial de l'après Brexit.

Dans cette étude, nous prenons pour hypothèse des scénarios de politique commerciale extrêmes, prenant en compte les développements récents des négociations en cours et les retournements politiques. Inférer des droits de douane et des distances MNT contrefactuels est la partie épineuse du problème, et les méthodes diffèrent énormément dans la littérature. Nous souhaitions être aussi précis que possible et prendre en compte non seulement les droits de douane et la distance, mais aussi les catégories de MNT. Les difficultés de convergence du modèle de gravité en équilibre général nous ont amené à restreindre les variables pour ne garder que les variables significatives, groupe par groupe, et à fixer σ à une valeur de 7 (sauf pour le groupe de la viande).

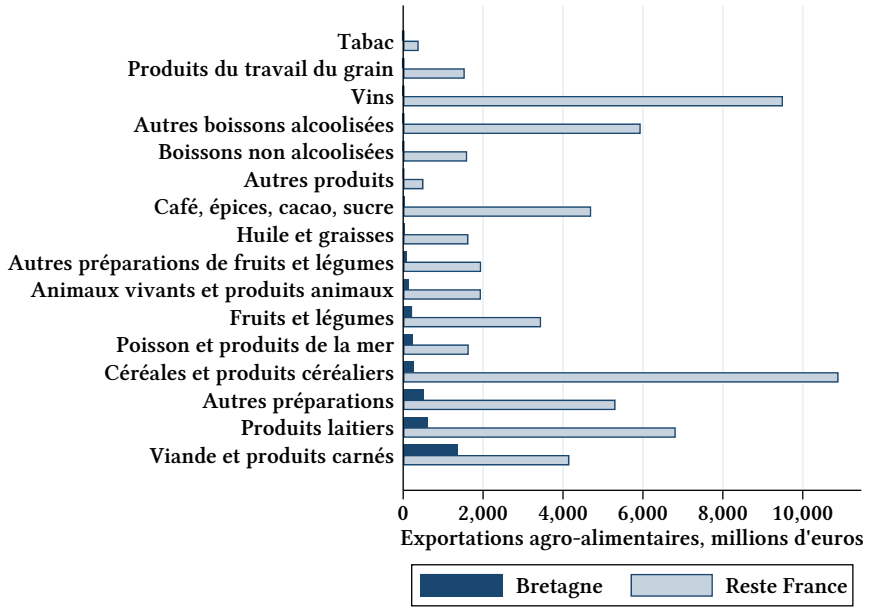
Les impacts sur les exportations bretonnes et françaises sont très proches au niveau de la variation en pourcentage. En revanche, le poids des différents groupes étant très différent aux niveaux national et régional, les impacts en valeurs sont plus différenciés, entre l'échelle régionale et nationale. La production alimentaire bretonne pourra se réorienter partiellement vers le marché européen, en particulier sous le scénario S2, mais c'est aussi le scénario qui engendre le plus de pertes en termes d'exportations vers le Royaume-Uni. La groupe de la viande est particulièrement impacté, sous tous les scénarios (mais dans une bien moindre mesure sous le scénario S1).

Nous apportons une réponse originale au manque de données régionales en proposant une méthode de prédiction de ces données. L'une des limites est la vérification de la robustesse de nos résultats, puisqu'une comparaison directe n'est pas possible et que les données de douanes et de production ne sont pas soumises aux mêmes nomenclatures et aux mêmes règles. C'est pourquoi nous avons recours à l'effet frontière pour vérifier la pertinence de nos résultats. Nous estimons un effet frontière faible par rapport aux valeurs de référence de la littérature. Nous corrigeons les flux intra- et inter-régionaux prédits de façon à atteindre un effet frontière correct. Cela suggère que, *ceteris paribus*, le modèle de gravité est moins pertinent pour l'estimation et la prédiction des flux intra-nationaux qu'il peut l'être pour les coûts et flux internationaux.

Enfin, plusieurs prolongements peuvent être envisagés. Tout d'abord, la présente étude pourrait être reproduite sur les autres régions françaises. Nous disposons en effet des données régionales nécessaires à l'extension du présent travail, avec toutefois les mêmes limites que celles évoquées précédemment. Une autre piste de travail serait le traitement de l'Irlande du Nord et de la Grande-Bretagne comme deux pays distincts, comme nous l'avons fait avec la Bretagne et le reste de la France. Ce traitement permettrait d'inférer des scénarios de politique commerciale entre ces deux régions, les frontières irlandaises étant au coeur des négociations post-Brexit.

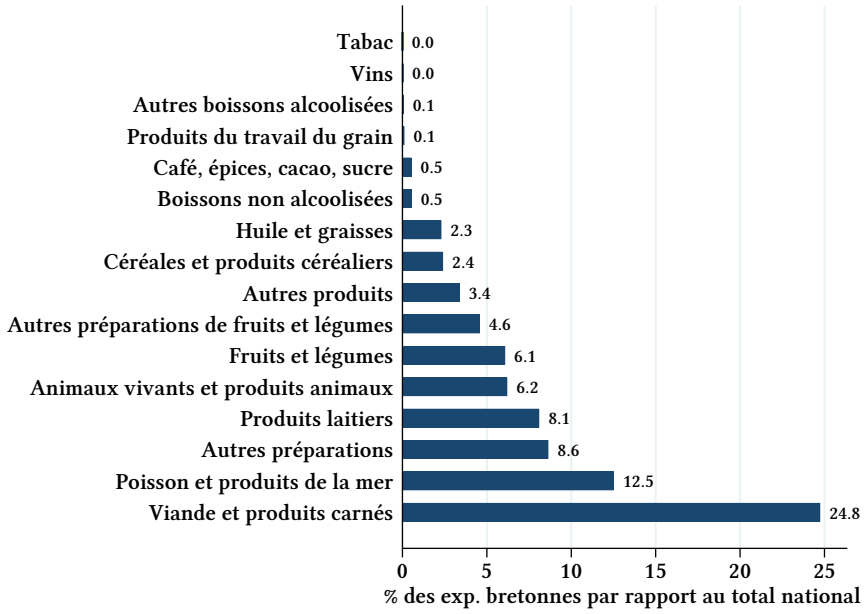
Annexe A – Figures et tableaux supplémentaires

Figure A1: Exportations agro-alimentaires de la Bretagne et du reste de la France (millions euros - 2015)



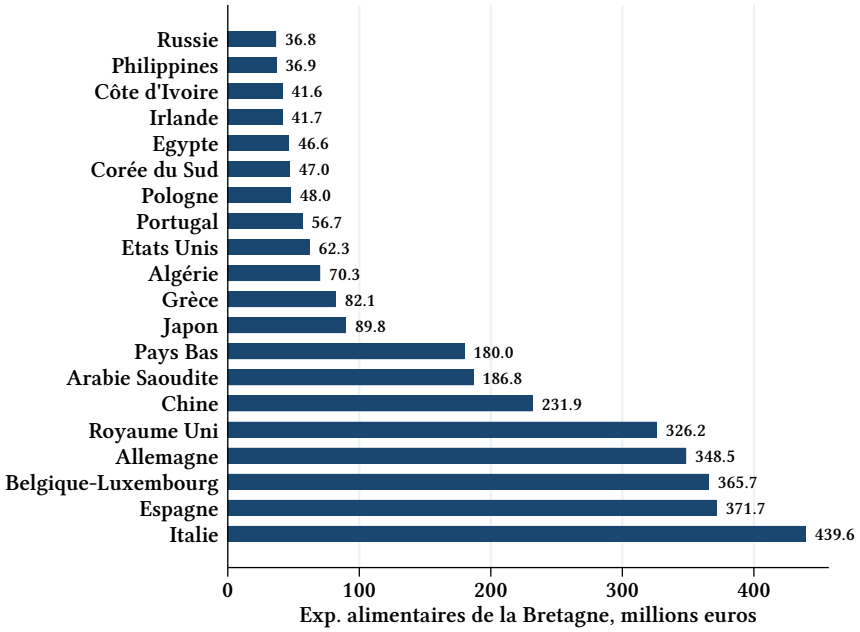
Source: Douanes régionales et BACI

Figure A2: Part de la Bretagne dans les exportations françaises agro-alimentaires en 2015



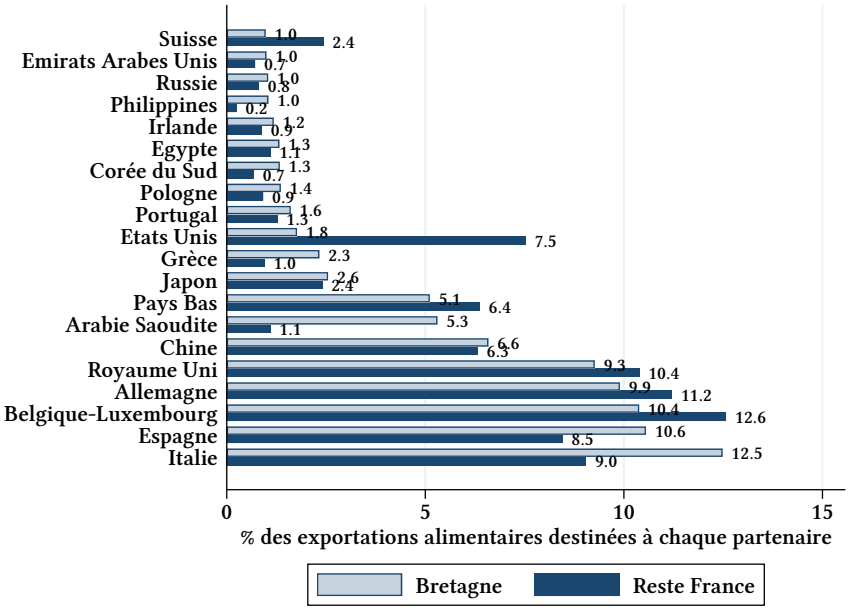
Source: Douanes régionales et BACI

Figure A3: Exportations agro-alimentaires de la Bretagne par destinataire, pour les 20 premières destinations (millions euros 2015)



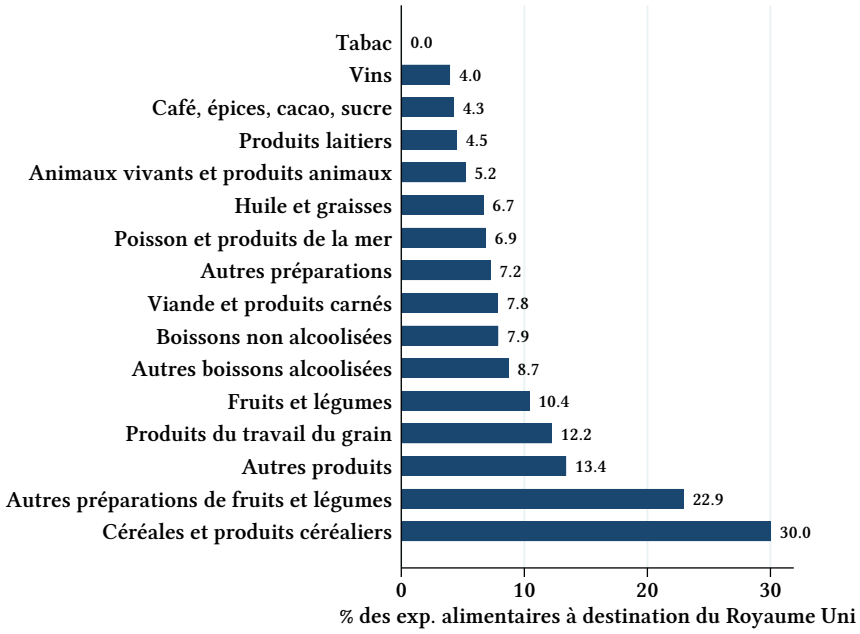
Source: Douanes régionales

Figure A4: Poids de chaque partenaire dans les exportations agro-alimentaires de la Bretagne et de la France en 2015



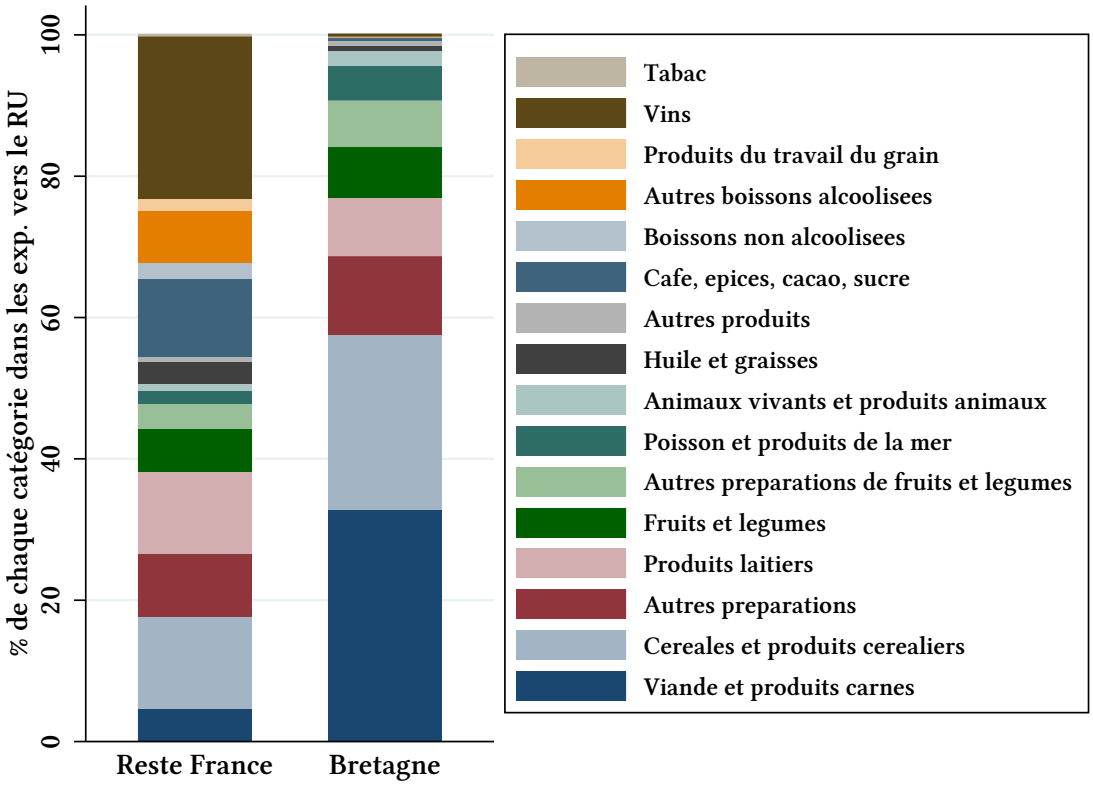
Source: Douanes régionales et BACI

Figure A5: Poids du Royaume-Uni dans les exportations de la Bretagne en 2015



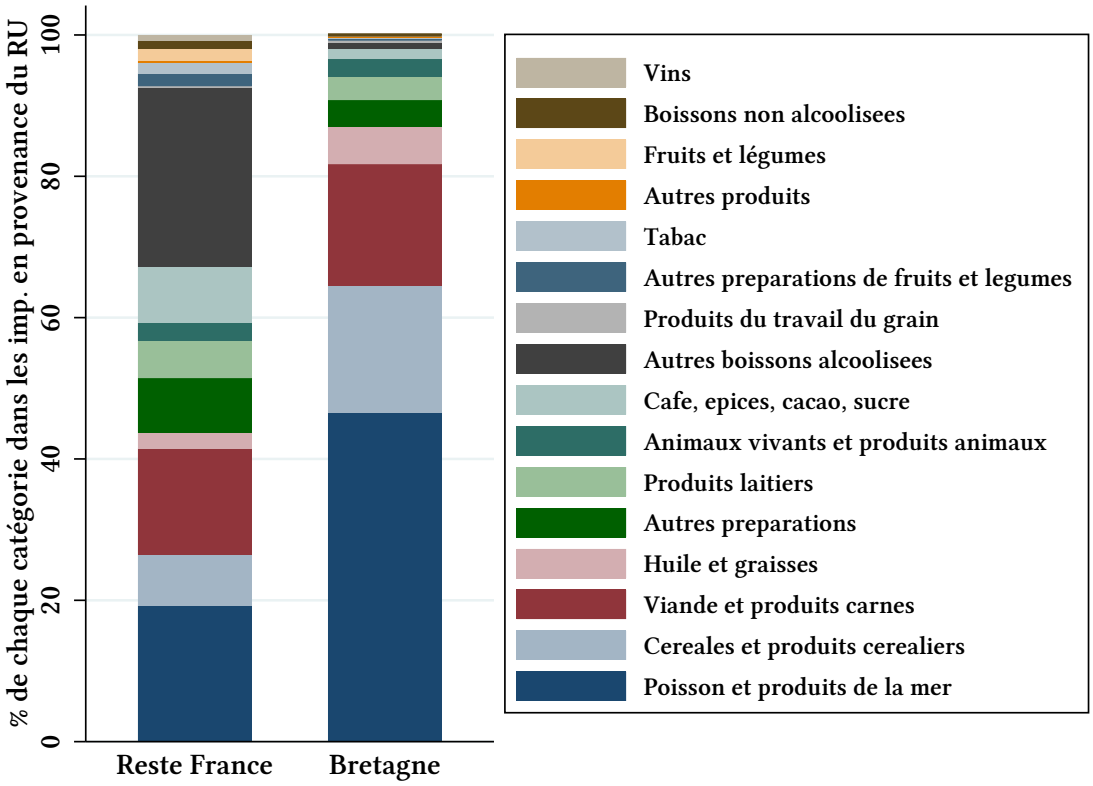
Source: Douanes régionales

Figure A6: Structure des exportations de la Bretagne et du reste de la France vers le Royaume-Uni en 2015



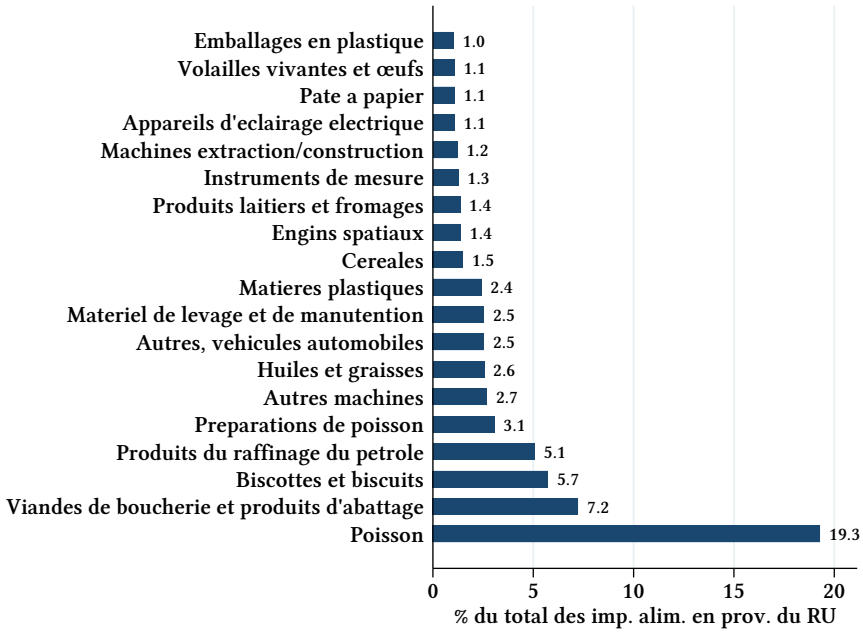
Source: Douanes régionales

Figure A7: Structure des importations de la Bretagne et de la France en provenance du Royaume-Uni, par catégorie, pour 2015



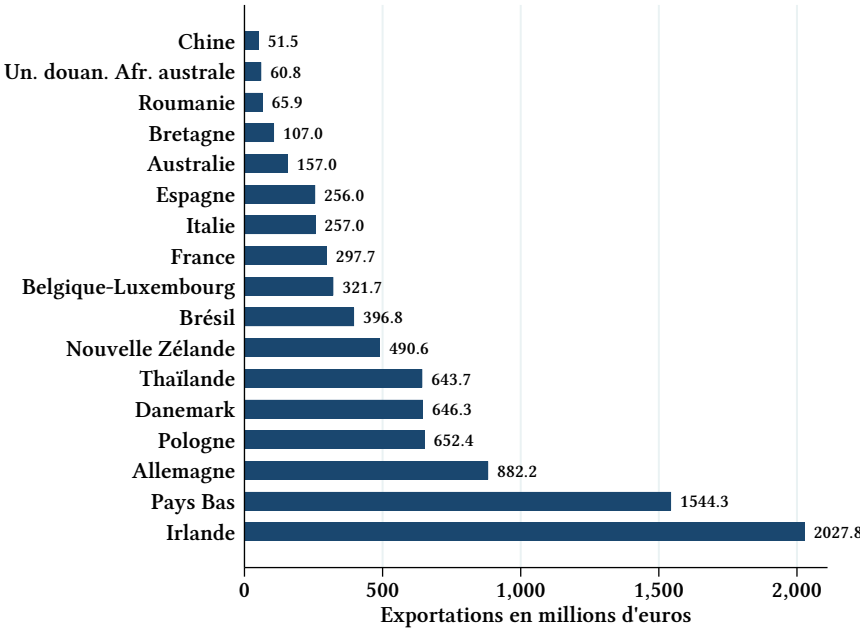
Source: Douanes régionales

Figure A8: Structure des importations de la Bretagne en provenance du Royaume-Uni par groupes de produits, tous produits, nomenclature CPF4 en 2015



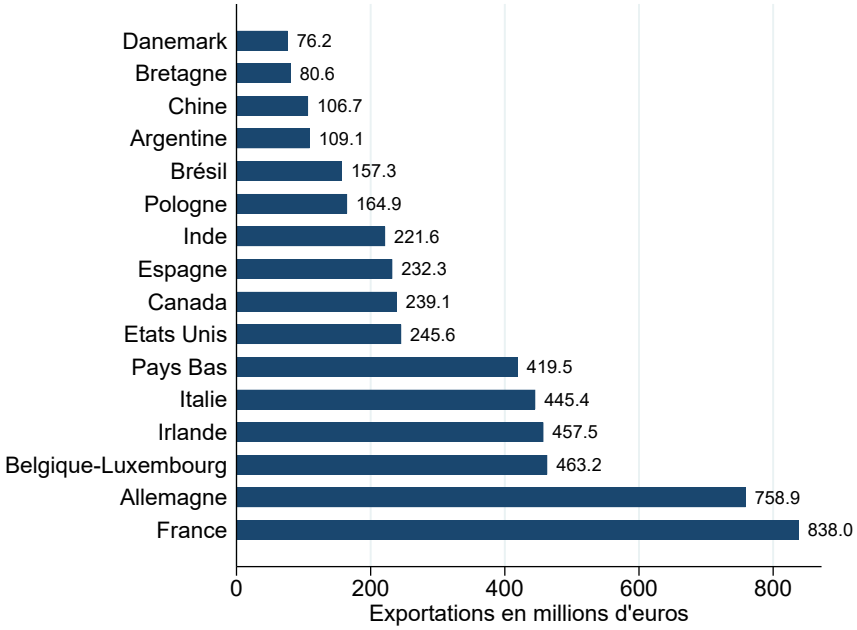
Source: Douanes régionales

Figure A9: Principaux exportateurs de la catégorie des viandes vers le Royaume-Uni (millions euros - 2015)



Source: Douanes régionales

Figure A10: Principaux exportateurs de la catégorie des céréales vers le Royaume-Uni (millions euros - 2015)



Source: Douanes régionales et BACI

Tableau A1: Chiffre d'affaires (CA) des IAA de la Bretagne et de la France en 2015

Catégories	Bretagne		France	
	(millions €)	part dans le secteur	(millions €)	part dans le secteur
Industrie des viandes	8 199	42.0 %	33 939	19,9 %
Industrie laitière	3 269	16.7 %	30 014	17,6 %
Fabrication d'aliments pour animaux	3 226	16.5 %	12 847	7,5 %
Autres produits alimentaires	1 656	8,5 %	26 194	15,4 %
Industrie des fruits et légumes	1 102	5.6 %	7 733	4.5 %
Fabrication de pain et pâtisserie	1 217	6.2 %	11 727	6.9 %
Industrie du poisson	650	3.3 %	3 677	2,2 %
Autres	139	0.7 %	14 553	8,5 %
Industrie des boissons	76	0.4 %	29 934	17,5 %
Total	19 534	100.0 %	170 617	100.0 %

Source: DRAAF Bretagne http://draaf.bretagne.agriculture.gouv.fr

Tableau A2: Scénarios détaillés

	UE-RU	RU avec les 6 ppx partenaires hors UE	RU avec le reste des non UE
Scénario 1 FTA avec UE et réplication des FTA de l'UE	tariff_{ijt}=0 (inchangé) $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} comme sous le régime MFN MNT_{ijt}^{E} inchangé	tariff_{ijt} inchangé $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} inchangé MNT_{ijt}^{E} inchangé	
Scénario 2 RU Forteresse	tariff_{ijt}=MFN tariff_{ijt} $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} comme sous le régime MFN MNT_{ijt}^{E} inchangé	tariff_{ijt} inchangé $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} inchangé MNT_{ijt}^{E} inchangé	tariff_{ijt} inchangé $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} inchangé MNT_{ijt}^{E} inchangé
Scénario 3 FTA avec UE et PTA avec les top non-UE	tariff_{ijt}=0 (inchangé) $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} comme sous le régime MFN MNT_{ijt}^{E} inchangé	tariff_{ijt}=0.5 · tariff_{ijt} $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C}=0.5 · MNT_{ijt}^{C} $\text{MNT}M_{ijt}^{E}$ inchangé	tariff_{ijt}=MFN tariff_{ijt} $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} comme sous le régime MFN MNT_{ijt}^{E} inchangé
Scénario 4 PTA avec les top non-UE et règles OMC avec le reste	tariff_{ijt}=MFN tariff_{ijt} =0 $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} comme sous le régime MFN MNT_{ijt}^{E} inchangé	tariff_{ijt}=0.5 · tariff_{ijt} $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} =0.5 · MNT_{ijt}^{C} MNT_{ijt}^{E} inchangé	tariff_{ijt}=MFN tariff_{ijt} $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} comme sous le régime MFN MNT_{ijt}^{E} inchangé
Scénario 5 RU libéralisé	tariff_{ijt}=0 (inchangé) $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} comme sous le régime MFN MNT_{ijt}^{E} inchangé	tariff_{ijt}=0 $\text{MNT}_{ijt}^{(A\&B)}$ inchangé MNT_{ijt}^{C} inchangé MNT_{ijt}^{E} inchangé	

Notes: FTA : Free Trade Agreement, PTA : Preferential Trade Agreement

Tableau A3: Classification des mesures non tarifaires (MNT)

	Type de MNT
A	Mesures sanitaires et phyto-sanitaires (SPS)
B	Mesures concernant les obstacles techniques au commerce (OTC)
C	Inspection avant expédition et autres formalités
D	Mesures contingentes de protection des échanges
E	Licences non automatiques, quotas, interdictions et autres mesures de contrôle des quantités
F	Mesures de contrôle des prix, y compris taxes et frais supplémentaires
...	...

Source et liste complète des MNT: https://unctad.org

Tableau A4: Ratio achats/ventes de la Bretagne par groupe de produits

	Total achats / Total ventes	
Groupe	Flux internationaux seulement	Avec les flux BR-FR
1. Animaux vivants et produits animaux	0,26	0,44
2. Autres boissons alcoolisées	5,39	7,20
3. Autres produits	2,59	2,30
4. Autres préparation	0,36	0,41
5. Autres préparations de fruits et légumes	1,70	1,52
6. Boissons non alcoolisées	0,61	0,88
7. Café, épices, cacao, sucre	4,31	4,10
8. Céréales et produits céréaliers	1,28	1,54
9. Fruits et légumes	0,59	0,54
10. Huile et graisses	10,45	9,22
11. Poisson et produits de la mer	1,93	1,66
12. Produits du travail du grain	13,55	21,11
13. Produits laitiers	0,50	0,67
14. Tabac	67,19	58,65
15. Viande et produits carnés	0,25	0,21
16. Vins	1,16	2,58

Notes: Une valeur inférieure à 1 signifie que la Bretagne est nette importatrice dans le groupe de produits en question; une valeur supérieure à 1 signifie que la Bretagne est nette exportatrice.

Tableau A5: Flux commerciaux et production agricole et alimentaire corrigés de la Bretagne par groupe de produits

Groupe de produits	Bretagne vers le reste de la France [estimé]	Bretagne vers l'étranger [douanes]	Exportations totales de la Bretagne	Conso domestique (flux intra Bretagne) [estimé]	Production bretonne
	(1)	(2)	(3)=(1)+(2)	(4)	(5)=(3)+(4)
1. Animaux viv. et prod. an.	198	165	363	46	409
2. Autres boissons alcoolisées	5	4	9	0	10
3. Autres produits	17	20	38	3	41
4. Autres préparations	686	539	1225	60	1286
5. Autres prép. fr. et lég.	152	112	264	20	284
6. Boissons non alcoolisées	14	9	22	0	23
7. Café, épices, cacao, sucre	40	27	67	2	69
8. Céréales et prod. cér.	312	343	655	79	734
9. Fruits et légumes	227	241	468	25	493
10. Huile et graisses	38	38	77	4	81
11. Poisson et prod. de la mer	310	294	604	61	665
12. Prod. du travail du grain	2	2	4	0	5
13. Produits laitiers	803	741	1545	175	1720
14. Tabac	0	0	0	0	0
15. Viande et produits carnés	2726	1496	4223	177	4399
16. Vins	2	4	6	0	6
Total	5533	4037	9569	653	10223

Notes: Millions euros - 2015 - Sources : Douanes, BACI, calcul et prédictions des auteures

Tableau A6: Flux commerciaux et production agricole et agro-alimentaire corrigés de la France hors Bretagne par groupe de produits

Groupe de produits	France vers la Bretagne [estimé]	France vers l'étranger [douanes]	Exportations totales de la France	Conso domestique (flux intra France) [estimé]	Production française
	(1)	(2)	(3)=(1)+(2)	(4)	(5)=(3)+(4)
1. Animaux viv. et prod. an.	194	2312	2506	509	3016
2. Autres boissons alcoolisées	72	11744	11816	5912	17728
3. Autres produits	15	1032	1046	564	1610
4. Autres préparations	406	7345	7751	2726	10477
5. Autres prép. fr. et lég.	147	3865	4012	2035	6047
6. Boissons non alcoolisées	23	2362	2385	791	3176
7. Café, épices, cacao, sucre	140	7901	8041	3333	11375
8. Céréales et prod. cér.	820	19526	20346	9517	29863
9. Fruits et légumes	68	6246	6313	3074	9387
10. Huile et graisses	150	2250	2399	694	3093
11. Poisson et prod. de la mer	214	2396	2609	1022	3632
12. Prod. du travail du grain	110	2110	2220	656	2877
13. Produits laitiers	998	10073	11071	4017	15087
14. Tabac	0	1013	1013	639	1653
15. Viande et produits carnés	332	4374	4706	1632	6337
16. Vins	31	12529	12560	3233	15793
Total	3719	97078	100796	40353	141150

Notes: Millions euros - 2015 - Sources : Douanes, BACI, calcul et prédictions des auteures

Tableau A7: Gravité groupes 1 et 2 avec différents σ

	1. Animaux vivants et produits animaux				2. Autres boissons alcoolisées			
	1-a	1-b	1-c	1-d	2-a	2-b	2-c	2-d
Domestique	0.678***	0.707***	0.740***	0.774***	0.515***	0.700***	0.711***	0.701***
	(0.220)	(0.214)	(0.209)	(0.205)	(0.135)	(0.187)	(0.207)	(0.215)
log(distance)	-0.926***	-0.923***	-0.909***	-0.895***	-0.910***	-0.754***	-0.738***	-0.738***
	(0.090)	(0.088)	(0.087)	(0.086)	(0.072)	(0.108)	(0.120)	(0.125)
Contiguité	1.782***	1.779***	1.785***	1.794***	0.469***	0.682***	0.729***	0.754***
	(0.192)	(0.187)	(0.185)	(0.183)	(0.145)	(0.182)	(0.199)	(0.208)
Langue	0.104	0.133	0.129	0.117	0.065	-0.043	-0.088	-0.128
	(0.170)	(0.174)	(0.177)	(0.177)	(0.115)	(0.158)	(0.166)	(0.170)
Colonie	1.006**	1.025**	1.052**	1.080***	-0.828**	-0.058	0.258	0.482
	(0.404)	(0.406)	(0.410)	(0.414)	(0.410)	(0.349)	(0.442)	(0.535)
log(1+tariff)	-1.749***	-4	-6	-8	0.036	-4	-6	-8
	(0.477)				(0.647)			
Dist.MNT.A.B	2.834**	3.872***	4.578***	5.263***	2.384***	1.925***	1.857***	1.848**
	(1.372)	(1.291)	(1.284)	(1.280)	(0.514)	(0.621)	(0.680)	(0.723)
Dist.MNT.C	1.530**	1.331*	1.274*	1.221	-3.649***	-4.404***	-4.600***	-4.714***
	(0.777)	(0.753)	(0.750)	(0.752)	(0.752)	(0.907)	(1.021)	(1.112)
Dist.MNT.E	-40.512***	-38.253***	-36.903***	-35.843***	-11.777	-2.131	3.140	8.029
	(4.413)	(4.114)	(3.983)	(3.889)	(8.269)	(10.089)	(10.923)	(11.738)
R^2	0.990	0.984	0.979	0.973	0.999	0.990	0.792	0.177
Observations	13,456	13,456	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : σ non fixé ; Colonne b : $\sigma = 5$; Colonne c : $\sigma = 7$; Colonne d: $\sigma = 9$

Tableau A8: Gravité groupes 3 et 4 avec différents σ

	3. Autres produits				4. Autres préparations			
	3-a	3-b	3-c	3-d	4-a	4-b	4-c	4-d
Domestique	0.328*	0.329*	0.327*	0.326*	0.246***	0.252***	0.259***	0.267***
	(0.195)	(0.195)	(0.195)	(0.195)	(0.092)	(0.094)	(0.096)	(0.099)
log(distance)	-0.953***	-0.956***	-0.951***	-0.946***	-0.747***	-0.737***	-0.729***	-0.724***
	(0.074)	(0.074)	(0.074)	(0.074)	(0.034)	(0.035)	(0.036)	(0.038)
Contiguité	0.283	0.280	0.284	0.288	0.500***	0.500***	0.500***	0.500***
	(0.178)	(0.178)	(0.178)	(0.179)	(0.119)	(0.117)	(0.116)	(0.114)
Langue	-0.156	-0.148	-0.161	-0.175	0.694***	0.656***	0.620***	0.585***
	(0.199)	(0.197)	(0.198)	(0.199)	(0.157)	(0.155)	(0.155)	(0.155)
Colonie	-0.314	-0.309	-0.317	-0.325	-0.937***	-0.915***	-0.899**	-0.889**
	(0.359)	(0.359)	(0.362)	(0.366)	(0.345)	(0.350)	(0.357)	(0.363)
log(1+tariff)	-5.189***	-4	-6	-8	-1.888***	-4	-6	-8
	(1.754)				(0.670)			
Dist.MNT.A.B	-2.369*	-2.503**	-2.277**	-2.050*	-0.325	0.171	0.629	1.066*
	(1.213)	(1.160)	(1.145)	(1.135)	(0.580)	(0.565)	(0.576)	(0.604)
Dist.MNT.C	-2.657***	-2.609***	-2.690***	-2.768***	1.838***	1.778***	1.756***	1.777***
	(0.685)	(0.679)	(0.682)	(0.689)	(0.514)	(0.545)	(0.597)	(0.673)
Dist.MNT.E	85.645***	80.186***	89.567***	99.818***	-11.447**	-8.601*	-5.751	-2.665
	(15.898)	(14.748)	(17.231)	(20.169)	(4.612)	(4.656)	(4.902)	(5.394)
R^2	0.997	0.997	0.997	0.997	0.950	0.902	0.813	0.675
Observations	13,456	13,456	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : σ non fixé ; Colonne b : $\sigma = 5$; Colonne c : $\sigma = 7$; Colonne d: $\sigma = 9$

Tableau A9: Gravité groupes 5 et 6 avec différents σ

	5. Autres préparations de fruits et légumes				6. Boissons non alcoolisées			
	5-a	5-b	5-c	5-d	6-a	6-b	6-c	6-d
Domestique	0.278**	0.255*	0.272**	0.291**	0.555***	0.584***	0.617***	0.644***
	(0.137)	(0.132)	(0.134)	(0.137)	(0.185)	(0.186)	(0.189)	(0.193)
log(distance)	-0.683***	-0.731***	-0.695***	-0.661***	-0.765***	-0.744***	-0.720***	-0.701***
	(0.051)	(0.046)	(0.048)	(0.050)	(0.067)	(0.066)	(0.065)	(0.065)
Contiguité	0.432***	0.440***	0.434***	0.427***	1.330***	1.356***	1.389***	1.419***
	(0.132)	(0.136)	(0.133)	(0.131)	(0.170)	(0.169)	(0.170)	(0.172)
Langue	0.184	0.199	0.187	0.177	0.091	0.083	0.070	0.054
	(0.133)	(0.136)	(0.133)	(0.132)	(0.158)	(0.156)	(0.155)	(0.156)
Colonie	0.722**	0.717***	0.720***	0.728**	0.465*	0.451*	0.441*	0.441*
	(0.282)	(0.268)	(0.278)	(0.290)	(0.277)	(0.273)	(0.268)	(0.264)
log(1+tariff)	-6.662***	-4	-6	-8	-2.493**	-4	-6	-8
	(0.748)				(1.023)			
Dist.MNT.A.B	1.265**	0.475	1.069**	1.658***	-6.399***	-6.031***	-5.563***	-5.119***
	(0.570)	(0.521)	(0.509)	(0.504)	(0.698)	(0.573)	(0.588)	(0.615)
Dist.MNT.C	0.182	0.287	0.209	0.123	-1.758***	-1.674***	-1.578***	-1.502**
	(0.490)	(0.487)	(0.487)	(0.504)	(0.583)	(0.592)	(0.589)	(0.599)
Dist.MNT.E	-21.916***	-22.307***	-22.013***	-21.712***	-12.306***	-12.623***	-13.132***	-13.669***
	(3.725)	(3.892)	(3.760)	(3.677)	(4.756)	(4.787)	(4.882)	(5.009)
R^2	0.947	0.938	0.914	0.868	1.000	1.000	0.999	0.999
Observations	13,456	13,456	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : σ non fixé ; Colonne b : $\sigma = 5$; Colonne c : $\sigma = 7$; Colonne d: $\sigma = 9$

Tableau A10: Gravité groupes 7 et 8 avec différents σ

	7. Café, épices, cacao, sucre				8. Céréales et produits céréaliers			
	7-a	7-b	7-c	7-d	8-a	8-b	8-c	8-d
Domestique	0.249**	0.255**	0.245**	0.237**	0.500***	0.511***	0.527***	0.550***
	(0.110)	(0.111)	(0.111)	(0.111)	(0.174)	(0.180)	(0.185)	(0.191)
log(distance)	-0.700***	-0.710***	-0.693***	-0.678***	-0.769***	-0.715***	-0.688***	-0.661***
	(0.036)	(0.034)	(0.034)	(0.034)	(0.070)	(0.073)	(0.077)	(0.082)
Contiguité	0.654***	0.660***	0.649***	0.638***	0.518***	0.507***	0.507***	0.512***
	(0.120)	(0.122)	(0.120)	(0.118)	(0.197)	(0.193)	(0.191)	(0.191)
Langue	0.219*	0.226*	0.214*	0.201*	0.105	0.067	0.045	0.022
	(0.120)	(0.122)	(0.119)	(0.117)	(0.156)	(0.153)	(0.154)	(0.158)
Colonie	-0.067	-0.066	-0.067	-0.067	1.421***	1.579***	1.683***	1.797***
	(0.225)	(0.222)	(0.228)	(0.235)	(0.377)	(0.379)	(0.390)	(0.404)
log(1+tariff)	-5.109***	-4	-6	-8	-0.209	-4	-6	-8
	(0.852)				(0.655)			
Dist.MNT.A.B	0.566	0.225	0.840**	1.455***	-3.649***	-2.819***	-2.367***	-1.914***
	(0.511)	(0.423)	(0.404)	(0.392)	(0.658)	(0.593)	(0.597)	(0.608)
Dist.MNT.C	0.446	0.570	0.350	0.149	-0.819**	-1.148***	-1.329***	-1.512***
	(0.465)	(0.457)	(0.450)	(0.448)	(0.398)	(0.406)	(0.421)	(0.440)
Dist.MNT.E	-0.052	-1.217	0.926	3.272	-31.673***	-27.057***	-25.161***	-23.590***
	(4.980)	(4.662)	(5.041)	(5.633)	(4.472)	(3.916)	(3.790)	(3.767)
R^2	0.872	0.857	0.822	0.763	0.961	0.928	0.825	0.672
Observations	13,456	13,456	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : σ non fixé ; Colonne b : $\sigma = 5$; Colonne c : $\sigma = 7$; Colonne d: $\sigma = 9$

Tableau A11: Gravité groupes 9 et 10 avec différents σ

	9. Fruits et légumes				10. Huile et graisses			
	9-a	9-b	9-c	9-d	10-a	10-b	10-c	10-d
Domestique	0.300*	0.293	0.308*	0.322*	0.011	0.058	0.075	0.092
	(0.180)	(0.180)	(0.179)	(0.179)	(0.228)	(0.247)	(0.260)	(0.273)
log(distance)	-0.912***	-0.925***	-0.896***	-0.870***	-0.678***	-0.612***	-0.588***	-0.564***
	(0.057)	(0.056)	(0.056)	(0.056)	(0.088)	(0.093)	(0.098)	(0.103)
Contiguité	0.481**	0.484**	0.476**	0.467**	0.555***	0.574***	0.584***	0.595***
	(0.188)	(0.189)	(0.186)	(0.183)	(0.200)	(0.201)	(0.204)	(0.208)
Langue	-0.159	-0.152	-0.169	-0.185	0.365**	0.350**	0.339*	0.327*
	(0.168)	(0.169)	(0.167)	(0.167)	(0.176)	(0.178)	(0.180)	(0.181)
Colonie	1.062***	1.054***	1.076***	1.108***	0.223	0.559*	0.717**	0.876**
	(0.264)	(0.265)	(0.263)	(0.264)	(0.283)	(0.322)	(0.365)	(0.418)
log(1+tariff)	-4.855***	-4	-6	-8	0.691	-4	-6	-8
	(0.836)				(0.927)			
Dist.MNT.A.B	-0.444	-0.625	-0.202	0.219	-2.588***	-1.712**	-1.321*	-0.932
	(0.663)	(0.614)	(0.615)	(0.620)	(0.735)	(0.688)	(0.692)	(0.701)
Dist.MNT.C	-0.622	-0.650*	-0.590	-0.553	-3.112***	-3.237***	-3.374***	-3.535***
	(0.380)	(0.378)	(0.386)	(0.401)	(0.630)	(0.618)	(0.631)	(0.646)
Dist.MNT.E	-28.072***	-27.996***	-28.181***	-28.375***	57.166***	59.287***	59.834***	60.431***
	(2.563)	(2.547)	(2.554)	(2.589)	(15.476)	(16.376)	(16.605)	(16.790)
R^2	0.979	0.976	0.972	0.962	0.825	0.719	0.530	0.355
Observations	13,456	13,456	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : σ non fixé ; Colonne b : $\sigma = 5$; Colonne c : $\sigma = 7$; Colonne d: $\sigma = 9$

Tableau A12: Gravité groupes 11 et 12 avec différents σ

	11. Poisson et produits de la mer				12. Produits du travail du grain			
	11-a	11-b	11-c	11-d	12-a	12-b	12-c	12-d
Domestique	0.069	0.115	0.134	0.153	0.312	0.202	0.342*	0.475**
	(0.171)	(0.179)	(0.184)	(0.190)	(0.192)	(0.209)	(0.194)	(0.188)
log(distance)	-0.630***	-0.541***	-0.507***	-0.474***	-0.753***	-0.789***	-0.744***	-0.705***
	(0.054)	(0.054)	(0.056)	(0.058)	(0.081)	(0.081)	(0.081)	(0.085)
Contiguité	0.271	0.288*	0.296*	0.303	1.164***	1.127***	1.175***	1.231***
	(0.165)	(0.174)	(0.180)	(0.185)	(0.161)	(0.169)	(0.166)	(0.169)
Langue	0.345**	0.249*	0.209	0.168	-0.156	-0.142	-0.161	-0.185
	(0.134)	(0.132)	(0.133)	(0.135)	(0.177)	(0.181)	(0.179)	(0.181)
Colonie	0.339	0.384	0.404	0.424	1.203***	1.195***	1.207***	1.235***
	(0.282)	(0.288)	(0.294)	(0.301)	(0.365)	(0.370)	(0.364)	(0.363)
log(1+tariff)	0.828	-4	-6	-8	-5.563***	-4	-6	-8
	(1.132)				(0.818)			
Dist.MNT.A.B	-3.860***	-3.309***	-3.088***	-2.873***	3.600***	2.453***	3.920***	5.367***
	(0.644)	(0.617)	(0.622)	(0.631)	(1.072)	(0.789)	(0.841)	(0.927)
Dist.MNT.C	-0.929*	-0.981*	-0.993*	-0.999*	-0.901	-0.316	-1.057	-1.724**
	(0.495)	(0.510)	(0.520)	(0.532)	(0.980)	(0.961)	(0.890)	(0.859)
Dist.MNT.E	-48.609***	-48.287***	-48.212***	-48.169***	-12.213**	-13.302**	-11.961**	-11.060**
	(2.909)	(2.668)	(2.616)	(2.588)	(4.959)	(5.230)	(4.864)	(4.667)
R^2	0.999	0.999	0.999	0.999	0.888	0.590	0.334	0.203
Observations	13,456	13,456	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : σ non fixé ; Colonne b : $\sigma = 5$; Colonne c : $\sigma = 7$; Colonne d: $\sigma = 9$

Tableau A13: Gravité groupes 13 et 14 avec différents σ

	13. Produits laitiers				14. Tabac			
	13-a	13-b	13-c	13-d	14-a	14-b	14-c	14-d
Domestique	0.423***	0.431***	0.445***	0.442***	0.186	0.185	0.177	0.160
	(0.162)	(0.162)	(0.163)	(0.165)	(0.229)	(0.227)	(0.228)	(0.231)
log(distance)	-0.761***	-0.761***	-0.771***	-0.792***	-0.738***	-0.723***	-0.717***	-0.720***
	(0.053)	(0.053)	(0.054)	(0.056)	(0.070)	(0.068)	(0.068)	(0.071)
Contiguité	0.853***	0.853***	0.854***	0.851***	-0.376*	-0.373	-0.371	-0.373
	(0.148)	(0.148)	(0.149)	(0.150)	(0.226)	(0.228)	(0.231)	(0.236)
Langue	0.333**	0.326**	0.306**	0.290**	0.198	0.197	0.185	0.162
	(0.136)	(0.135)	(0.135)	(0.138)	(0.203)	(0.207)	(0.213)	(0.220)
Colonie	-0.236	-0.243	-0.253	-0.248	-0.156	-0.131	-0.093	-0.058
	(0.552)	(0.555)	(0.564)	(0.572)	(0.278)	(0.285)	(0.300)	(0.325)
log(1+tariff)	-3.404***	-4	-6	-8	-2.255***	-4	-6	-8
	(0.453)				(0.530)			
Dist.MNT.A.B	0.398	0.791	2.074***	3.253***	-6.255***	-4.272***	-1.933	0.463
	(0.769)	(0.752)	(0.764)	(0.818)	(1.516)	(1.409)	(1.473)	(1.576)
Dist.MNT.C	-0.400	-0.432	-0.516	-0.560	2.972***	3.363***	3.721***	3.979***
	(0.422)	(0.426)	(0.434)	(0.459)	(0.988)	(1.023)	(1.118)	(1.261)
Dist.MNT.E	-17.243***	-16.365***	-14.039***	-12.552***	51.695***	54.223***	57.958***	62.434***
	(3.149)	(2.986)	(2.996)	(3.292)	(9.818)	(11.812)	(14.127)	(16.376)
R^2	0.928	0.663	0.169	0.029	0.908	0.869	0.772	0.598
Observations	13,456	13,456	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : σ non fixé ; Colonne b : $\sigma = 5$; Colonne c : $\sigma = 7$; Colonne d: $\sigma = 9$

Tableau A14: Gravité groupes 15 et 16 avec différents σ

	15. Viande et produits carnés				16. Vins			
	15-a	15-b	15-c	15-d	16-a	16-b	16-c	16-d
Domestique	0.364**	0.634***	0.812***	0.967***	0.100	0.155	0.197	0.239
	(0.153)	(0.145)	(0.154)	(0.166)	(0.224)	(0.226)	(0.227)	(0.229)
log(distance)	-0.480***	-0.358***	-0.276***	-0.201***	-0.514***	-0.502***	-0.493***	-0.484***
	(0.061)	(0.059)	(0.063)	(0.068)	(0.079)	(0.081)	(0.084)	(0.088)
Contiguité	0.944***	0.990***	1.022***	1.052***	0.052	0.058	0.063	0.068
	(0.140)	(0.136)	(0.137)	(0.141)	(0.246)	(0.246)	(0.246)	(0.246)
Langue	0.538***	0.525***	0.512***	0.494***	0.607***	0.589***	0.578***	0.568***
	(0.160)	(0.146)	(0.141)	(0.141)	(0.150)	(0.149)	(0.153)	(0.159)
Colonie	2.664***	2.866***	3.029***	3.194***	-0.126	-0.067	-0.006	0.069
	(0.606)	(0.577)	(0.572)	(0.574)	(0.409)	(0.419)	(0.432)	(0.453)
log(1+tariff)	-1.339**	-4	-6	-8	-1.328	-4	-6	-8
	(0.562)				(1.692)			
Dist.MNT.A.B	-0.051	0.788	1.374	1.904**	1.117*	1.702***	2.159***	2.633***
	(0.915)	(0.830)	(0.841)	(0.869)	(0.645)	(0.540)	(0.543)	(0.553)
Dist.MNT.C	-1.350*	-1.383**	-1.384*	-1.360*	2.335**	2.319**	2.325**	2.347**
	(0.700)	(0.706)	(0.727)	(0.759)	(0.958)	(0.950)	(0.959)	(0.992)
Dist.MNT.E	-72.784***	-68.795***	-67.345***	-66.784***	-21.810***	-20.971***	-20.341***	-19.728***
	(4.337)	(3.786)	(3.532)	(3.466)	(5.860)	(5.492)	(5.527)	(5.804)
R^2	1.000	1.000	0.999	0.996	0.872	0.801	0.616	0.205
Observations	13,456	13,456	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : σ non fixé ; Colonne b : $\sigma = 5$; Colonne c : $\sigma = 7$; Colonne d: $\sigma = 9$

Tableau A15: Gravité groupes 1 et 2 - variables significatives et non significatives

	1. Animaux vivants et produits animaux			2. Autres boissons alcoolisées		
	1-a	1-b	1-c	2-a	2-b	2-c
Domestique	0.678***	0.681***	0.746***	0.515***	0.491***	0.491***
	(0.220)	(0.220)	(0.210)	(0.135)	(0.138)	(0.138)
log(distance)	-0.926***	-0.923***	-0.904***	-0.910***	-0.926***	-0.926***
	(0.090)	(0.089)	(0.087)	(0.072)	(0.068)	(0.068)
Contiguité	1.782***	1.810***	1.820***	0.469***	0.502***	0.502***
	(0.192)	(0.181)	(0.175)	(0.145)	(0.141)	(0.141)
Langue	0.104			0.065		
	(0.170)			(0.115)		
Colonie	1.006**	1.047***	1.102***	-0.828**	-0.807**	-0.807**
	(0.404)	(0.391)	(0.398)	(0.410)	(0.391)	(0.391)
log(1+tariff)	-1.749***	-1.714***	-6	0.036		
	(0.477)	(0.485)		(0.647)		
Dist.MNT.A.B	2.834**	2.800**	4.540***	2.384***	2.189***	2.189***
	(1.372)	(1.370)	(1.275)	(0.514)	(0.462)	(0.462)
Dist.MNT.C	1.530**	1.578**	1.329*	-3.649***	-3.724***	-3.724***
	(0.777)	(0.775)	(0.740)	(0.752)	(0.775)	(0.775)
Dist.MNT.E	-40.512***	-40.527***	-36.831***	-11.777		
	(4.413)	(4.426)	(3.960)	(8.269)		
R^2	0.990	0.990	0.981	0.999	0.999	0.999
Observations	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : toutes les var. ; Colonne b : uniquement les var. significatives ; Colonne c : uniquement les var. significatives et $\sigma = 7$

Tableau A16: Gravité groupes 3 et 4 - variables significatives et non significatives

	3. Autres produits			4. Autres préparations		
	3-a	3-b	3-c	4-a	4-b	4-c
Domestique	0.328*	0.156	0.156	0.246***	0.265***	0.218**
	(0.195)	(0.136)	(0.136)	(0.092)	(0.099)	(0.105)
log(distance)	-0.953***	-1.003***	-1.001***	-0.747***	-0.750***	-0.721***
	(0.074)	(0.054)	(0.054)	(0.034)	(0.034)	(0.035)
Contiguité	0.283			0.500***	0.502***	0.498***
	(0.178)			(0.119)	(0.120)	(0.117)
Langue	-0.156			0.694***	0.684***	0.637***
	(0.199)			(0.157)	(0.163)	(0.161)
Colonie	-0.314			-0.937***	-0.934***	-0.902**
	(0.359)			(0.345)	(0.346)	(0.359)
log(1+tariff)	-5.189***	-5.025***	-6	-1.888***	-2.048***	-6
	(1.754)	(1.750)		(0.670)	(0.669)	
Dist.MNT.A.B	-2.369*	-2.492**	-2.388**	-0.325		
	(1.213)	(1.159)	(1.103)	(0.580)		
Dist.MNT.C	-2.657***	-2.781***	-2.819***	1.838***	1.797***	1.883***
	(0.685)	(0.682)	(0.681)	(0.514)	(0.505)	(0.608)
Dist.MNT.E	85.645***	83.717***	88.323***	-11.447**	-13.023***	-1.618
	(15.898)	(15.891)	(17.187)	(4.612)	(3.148)	(3.096)
R^2	0.997	0.997	0.997	0.950	0.950	0.819
Observations	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : toutes les var. ; Colonne b : uniquement les var. significatives ; Colonne c : uniquement les var. significatives et $\sigma = 7$

Tableau A17: Gravité groupes 5 et 6 - variables significatives et non significatives

	5. Autres préparations de fruits et légumes			6. Boissons non alcoolisées		
	5-a	5-b	5-c	6-a	6-b	6-c
Domestique	0.278**	0.251*	0.244*	0.555***	0.553***	0.615***
	(0.137)	(0.134)	(0.131)	(0.185)	(0.185)	(0.188)
log(distance)	-0.683***	-0.693***	-0.706***	-0.765***	-0.764***	-0.719***
	(0.051)	(0.050)	(0.046)	(0.067)	(0.067)	(0.065)
Contiguité	0.432***	0.477***	0.481***	1.330***	1.369***	1.418***
	(0.132)	(0.124)	(0.124)	(0.170)	(0.160)	(0.162)
Langue	0.184			0.091		
	(0.133)			(0.158)		
Colonie	0.722**	0.736***	0.736***	0.465*	0.501*	0.468*
	(0.282)	(0.281)	(0.277)	(0.277)	(0.262)	(0.255)
log(1+tariff)	-6.662***	-6.732***	-6	-2.493**	-2.520**	-6
	(0.748)	(0.742)		(1.023)	(1.020)	
Dist.MNT.A.B	1.265**	1.358***	1.145**	-6.399***	-6.330***	-5.517***
	(0.570)	(0.526)	(0.467)	(0.698)	(0.647)	(0.552)
Dist.MNT.C	0.182			-1.758***	-1.712***	-1.548***
	(0.490)			(0.583)	(0.587)	(0.594)
Dist.MNT.E	-21.916***	-20.872***	-20.912***	-12.306***	-12.329***	-13.114***
	(3.725)	(3.778)	(3.823)	(4.756)	(4.727)	(4.854)
R^2	0.947	0.948	0.914	1.000	1.000	0.999
Observations	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : toutes les var. ; Colonne b : uniquement les var. significatives ; Colonne c : uniquement les var. significatives et $\sigma = 7$

Tableau A18: Gravité groupes 7 et 8 - variables significatives et non significatives

	7. Café, épices, cacao, sucre			8. Céréales et produits céréaliers		
	7-a	7-b	7-c	8-a	8-b	8-c
Domestique	0.249**	0.209*	0.176	0.500***	0.484***	0.484***
	(0.110)	(0.109)	(0.112)	(0.174)	(0.177)	(0.177)
log(distance)	-0.700***	-0.688***	-0.663***	-0.769***	-0.780***	-0.780***
	(0.036)	(0.037)	(0.034)	(0.070)	(0.069)	(0.069)
Contiguité	0.654***	0.656***	0.649***	0.518***	0.537***	0.537***
	(0.120)	(0.122)	(0.121)	(0.197)	(0.186)	(0.186)
Langue	0.219*	0.239**	0.244**	0.105		
	(0.120)	(0.117)	(0.116)	(0.156)		
Colonie	-0.067			1.421***	1.444***	1.444***
	(0.225)			(0.377)	(0.361)	(0.361)
log(1+tariff)	-5.109***	-4.630***	-6	-0.209		
	(0.852)	(0.649)		(0.655)		
Dist.MNT.A.B	0.566			-3.649***	-3.591***	-3.591***
	(0.511)			(0.658)	(0.557)	(0.557)
Dist.MNT.C	0.446			-0.819**	-0.764*	-0.764*
	(0.465)			(0.398)	(0.400)	(0.400)
Dist.MNT.E	-0.052			-31.673***	-32.524***	-32.524***
	(4.980)			(4.472)	(4.595)	(4.595)
R^2	0.872	0.867	0.826	0.961	0.961	0.961
Observations	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : toutes les var. ; Colonne b : uniquement les var. significatives ; Colonne c : uniquement les var. significatives et $\sigma = 7$

Tableau A19: Gravité groupes 9 et 10 - variables significatives et non significatives

	9. Fruits et légumes			10. Huile et graisses		
	9-a	9-b	9-c	10-a	10-b	10-c
Domestique	0.300*	0.380**	0.367**	0.011		
	(0.180)	(0.167)	(0.167)	(0.228)		
log(distance)	-0.912***	-0.916***	-0.899***	-0.678***	-0.678***	-0.678***
	(0.057)	(0.058)	(0.057)	(0.088)	(0.062)	(0.062)
Contiguité	0.481**	0.451**	0.448**	0.555***	0.551***	0.551***
	(0.188)	(0.177)	(0.177)	(0.200)	(0.157)	(0.157)
Langue	-0.159			0.365**	0.356**	0.356**
	(0.168)			(0.176)	(0.173)	(0.173)
Colonie	1.062***	0.997***	1.003***	0.223		
	(0.264)	(0.254)	(0.254)	(0.283)		
log(1+tariff)	-4.855***	-5.182***	-6	0.691		
	(0.836)	(0.780)		(0.927)		
Dist.MNT.A.B	-0.444			-2.588***	-2.445***	-2.445***
	(0.663)			(0.735)	(0.695)	(0.695)
Dist.MNT.C	-0.622			-3.112***	-3.116***	-3.116***
	(0.380)			(0.630)	(0.599)	(0.599)
Dist.MNT.E	-28.072***	-30.324***	-30.243***	57.166***	59.079***	59.079***
	(2.563)	(2.587)	(2.594)	(15.476)	(15.820)	(15.820)
R^2	0.979	0.979	0.972	0.825	0.824	0.824
Observations	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : toutes les var. ; Colonne b : uniquement les var. significatives ; Colonne c : uniquement les var. significatives et $\sigma = 7$

Tableau A20: Gravité groupes 11 et 12 - variables significatives et non significatives

	11. Poisson et produits de la mer			12. Produits du travail du grain		
	11-a	11-b	11-c	12-a	12-b	12-c
Domestique	0.069			0.312		
	(0.171)			(0.192)		
log(distance)	-0.630***	-0.660***	-0.660***	-0.753***	-0.827***	-0.823***
	(0.054)	(0.032)	(0.032)	(0.081)	(0.063)	(0.066)
Contiguité	0.271			1.164***	0.977***	0.968***
	(0.165)			(0.161)	(0.115)	(0.115)
Langue	0.345**	0.386***	0.386***	-0.156		
	(0.134)	(0.121)	(0.121)	(0.177)		
Colonie	0.339			1.203***	1.105***	1.098***
	(0.282)			(0.365)	(0.356)	(0.354)
log(1+tariff)	0.828			-5.563***	-5.082***	-6
	(1.132)			(0.818)	(0.793)	
Dist.MNT.A.B	-3.860***	-3.509***	-3.509***	3.600***	2.876***	3.444***
	(0.644)	(0.535)	(0.535)	(1.072)	(1.100)	(0.918)
Dist.MNT.C	-0.929*	-1.083**	-1.083**	-0.901		
	(0.495)	(0.488)	(0.488)	(0.980)		
Dist.MNT.E	-48.609***	-48.134***	-48.134***	-12.213**	-13.817***	-13.797***
	(2.909)	(2.889)	(2.889)	(4.959)	(4.435)	(4.335)
R^2	0.999	0.999	0.999	0.888	0.883	0.343
Observations	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : toutes les var. ; Colonne b : uniquement les var. significatives ; Colonne c : uniquement les var. significatives et $\sigma = 7$

Tableau A21: Gravité groupes 13 et 14 - variables significatives et non significatives

	13. Produits laitiers			14. Tabac		
	13-a	13-b	13-c	14-a	14-b	14-c
Domestique	0.423***	0.437***	0.413***	0.186		
	(0.162)	(0.160)	(0.160)	(0.229)		
log(distance)	-0.761***	-0.758***	-0.737***	-0.738***	-0.782***	-0.756***
	(0.053)	(0.052)	(0.053)	(0.070)	(0.039)	(0.039)
Contiguité	0.853***	0.862***	0.846***	-0.376*	-0.418**	-0.411**
	(0.148)	(0.147)	(0.144)	(0.226)	(0.166)	(0.171)
Langue	0.333**	0.327**	0.371***	0.198		
	(0.136)	(0.129)	(0.131)	(0.203)		
Colonie	-0.236			-0.156		
	(0.552)			(0.278)		
log(1+tariff)	-3.404***	-3.365***	-6	-2.255***	-2.251***	-6
	(0.453)	(0.439)		(0.530)	(0.538)	
Dist.MNT.A.B	0.398			-6.255***	-6.148***	-1.857
	(0.769)			(1.516)	(1.495)	(1.453)
Dist.MNT.C	-0.400			2.972***	2.734***	3.497***
	(0.422)			(0.988)	(0.948)	(1.075)
Dist.MNT.E	-17.243***	-17.269***	-11.257***	51.695***	51.291***	57.014***
	(3.149)	(2.905)	(2.762)	(9.818)	(9.415)	(13.729)
R^2	0.928	0.928	0.215	0.908	0.906	0.772
Observations	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : toutes les var. ; Colonne b : uniquement les var. significatives ; Colonne c : uniquement les var. significatives et $\sigma = 7$

Tableau A22: Gravité groupes 15 et 16 - variables significatives et non significatives

	15. Viande et produits carnés			16. Vins		
	15-a	15-b	15-c	16-a	16-b	16-c
Domestique	0.364**	0.368**	0.719***	0.100		
	(0.153)	(0.144)	(0.147)	(0.224)		
log(distance)	-0.480***	-0.480***	-0.255***	-0.514***	-0.532***	-0.532***
	(0.061)	(0.062)	(0.064)	(0.079)	(0.059)	(0.059)
Contiguité	0.944***	0.943***	1.038***	0.052		
	(0.140)	(0.142)	(0.145)	(0.246)		
Langue	0.538***	0.537***	0.556***	0.607***	0.622***	0.622***
	(0.160)	(0.161)	(0.149)	(0.150)	(0.126)	(0.126)
Colonie	2.664***	2.668***	2.943***	-0.126		
	(0.606)	(0.594)	(0.556)	(0.409)		
log(1+tariff)	-1.339**	-1.349***	-6	-1.328		
	(0.562)	(0.520)		(1.692)		
Dist.MNT.A.B	-0.051			1.117*	0.823	0.823
	(0.915)			(0.645)	(0.547)	(0.547)
Dist.MNT.C	-1.350*	-1.369***	-0.849*	2.335**	2.266**	2.266**
	(0.700)	(0.472)	(0.482)	(0.958)	(1.000)	(1.000)
Dist.MNT.E	-72.784***	-72.861***	-65.784***	-21.810***	-22.507***	-22.507***
	(4.337)	(4.130)	(3.354)	(5.860)	(6.094)	(6.094)
R^2	1.000	1.000	0.999	0.872	0.872	0.872
Observations	13,456	13,456	13,456	13,456	13,456	13,456

Niveau de significativité: ***0.01 **0.05 *0.10 ; Colonne a : toutes les var. ; Colonne b : uniquement les var. significatives ; Colonne c : uniquement les var. significatives et $\sigma = 7$

Tableau A23: Évolution des exportations du reste de la France vers le RU, en %, avec $\sigma = 7$

Catégorie	S1	S2	S3	S4	S5
1. Animaux vivants et produits animaux	3.93	-33.96	4.57	-33.18	-17.08
2. Autres boissons alcoolisées	-16.09	-16.09	-16.45	-16.45	-16.09
3. Autres produits	-3.43	-20.72	-1.51	-17.46	-9.30
4. Autres préparations	3.71	-25.85	1.77	-28.84	-17.64
5. Autres préparations de fruits et légumes	0.00	-33.00	4.65	-27.72	-21.78
6. Boissons non alcoolisées	-2.57	-24.66	-1.88	-24.52	-12.40
7. Café, épices, cacao, sucre	0.00	-41.01	7.12	-34.07	-23.66
8. Céréales et produits céréaliers	-2.39	-2.39	-2.59	-2.59	-2.39
9. Fruits et légumes	0.00	-35.61	4.26	-30.81	-24.36
10. Huile et graisses	-10.65	-10.65	-7.51	-7.51	-10.65
11. Poisson et produits de la mer	-4.03	-4.03	-6.55	-6.55	-4.03
12. Produits du travail du grain	0.00	-20.81	-10.60	-37.26	-38.93
13. Produits laitiers	0.00	-18.21	0.96	-19.31	-20.38
14. Tabac	5.77	-19.33	5.37	-20.06	-15.76
15. Viande et produits carnés	-1.65	-29.08	-17.68	-52.52	-56.35
16. Vins	2.80	2.80	3.53	3.53	2.80

Notes: Calcul par les auteures selon la procédure expliquée dans la section 3.2 en fixant $\sigma = 7$ (sauf pour le groupe de la viande)

Tableau A24: Évolution des exportations de la Bretagne vers tous les destinataires, en %, avec $\sigma = 7$

Catégorie	S1	S2	S3	S4	S5
1. Animaux vivants et produits animaux	-0.01	-0.39	-0.20	-0.59	0.39
2. Autres boissons alcoolisées	0.09	0.09	0.26	0.26	0.09
3. Autres produits	-0.34	-2.05	-0.22	-1.91	-0.13
4. Autres préparations	0.02	-0.89	0.25	-0.89	-0.13
5. Autres préparations de fruits et légumes	0.00	-2.36	0.49	-1.82	-0.38
6. Boissons non alcoolisées	-0.04	-0.91	0.03	-0.53	-0.03
7. Café, épices, cacao, sucre	0.00	-1.87	0.97	-0.79	-0.12
8. Céréales et produits céréaliers	-0.04	-0.04	-0.05	-0.05	-0.04
9. Fruits et légumes	0.00	-3.01	0.15	-2.66	-2.87
10. Huile et graisses	-0.34	-0.34	-0.24	-0.24	-0.34
11. Poisson et produits de la mer	-0.06	-0.06	-0.09	-0.09	-0.06
12. Produits du travail du grain	0.00	-0.66	-0.49	-1.56	-0.92
13. Produits laitiers	0.00	-0.32	0.48	-0.36	-1.91
14. Tabac	25.39	25.21	25.70	25.47	25.30
15. Viande et produits carnés	-0.04	-2.62	-3.05	-2.37	-2.95
16. Vins	-0.05	-0.05	-0.05	-0.05	-0.05

Notes: Calcul par les auteures selon la procédure expliquée dans la section 3.2 en fixant $\sigma = 7$ (sauf pour le groupe de la viande)

Annexe B – Traitement des données

1. Périmètres et compatibilité des bases de données.

Concernant la nomenclature CPF4, nous ne conservons que les catégories comprises entre 0 et 0300 d'une part, et entre 1011 et 1200 d'autre part (*i.e.* les CPF2 01 à 03 et 10 à 12). Cela recoupe presque exactement les chapitres 1 à 24 du Système Harmonisé. Les rares catégories HS6 non recouvertes représentent de faibles valeurs.

Les données commerciales nationales issues des douanes (LeKiosque) présentent de faibles différences avec celles de BACI. Nous choisissons de conserver les données de BACI pour l'exercice de simulation avec le modèle de gravité. Ainsi, nous calculons le pourcentage Bretagne/France à partir des données de douanes et reconstituons la valeur des exportations et des importations de la Bretagne à partir de ce pourcentage (des douanes) et des valeurs nationales (de BACI).

2. Agrégation en 16 groupes.

L'agrégation choisie est compatible à la fois avec les données LeKiosque (CPF4) et celles de la base issue de BACI (SH6).

3. Coûts à l'échange entre la Bretagne et le reste du monde.

Les coûts à l'échange entre la Bretagne et le reste du monde sont définis en répliquant simplement les coûts à l'échange entre la France et le reste du monde. On distingue cependant la Bretagne du reste de la France les variables de la contiguité et des distances simples avec les proches voisins (Allemagne, Suisse, Italie, Belgique, Royaume-Uni, Irlande). On utilise pour le calcul de la distance simple la distance à vol d'oiseau entre les deux villes les plus peuplées: Rennes pour la Bretagne, Paris pour la France.

4. Distances et création du pays France/BR (France sans la Bretagne).

Nous calculons les distances intérieures non pondérées, utiles pour le calcul des flux domestiques (en suivant les formules du CEPII):

$$dist_{ii} = 0.67 * \sqrt{\frac{aire}{\pi}} \tag{15}$$

Pour la France, cette valeur est d'environ 279 km. Nous la calculons pour la Bretagne (BR) et la France hors Bretagne (FR/BR):

$$dist_{BR-BR} = 0.67 * \sqrt{\frac{34023}{\pi}} = 69.72km \tag{16}$$

$$dist_{FR/BR-FR/BR} = 0.67 * \sqrt{\frac{547028 - 34023}{\pi}} = 270.74km \tag{17}$$

Nous calculons ensuite les distances pondérées $distw$:

$$distw_{kl} = \sum_{k \in i} \left(\frac{pop_k}{pop_i} \right) \sum_{l \in j} \left(\frac{pop_l}{pop_j} \right) d_{kl} \tag{18}$$

Avec pop_k la population de l'agglomération k qui appartient au pays i, pop_l la population de l'agglomération l qui appartient au pays j, d_{kl} la distance entre les villes k et l. Les résultats sont résumés dans le Tableau B1.

Tableau B1: Distances

Type de distance	Pays	Valeur (km)
dist simple intra	France	279,58
dist simple intra	Bretagne	69,72
dist simple intra	France hors Bretagne	270,74
dist simple	Bretagne - Reste de la France	522,81
distw intra	France	417,03
distw intra	Bretagne	110,57
distw intra	France hors Bretagne	344,22
distw	Bretagne - Reste de la France	522,81

Source: Calcul par les auteures

Les $distw$ seront utilisées pour les estimations des flux intra- et inter-régionaux, et les distances simples pour les simulations. Notre valeur de la $distw$ intra-France se rapproche de 408 km, qui est la valeur données par le CEPII. L'inconvénient pour le calcul des $distw$, suivant l'équation (18), est qu'il faut constituer une base de données des plus grandes villes de chaque pays, leur population, et la distance entre les plus grandes villes du pays i et du pays j. C'est pourquoi nous calculons cette distance pour la paire Bretagne-Reste de la France, mais pour les $distw$ entre la Bretagne et le reste du monde nous faisons l'hypothèse que ce sont les mêmes que celles entre la France/BR et le reste du monde.

Pour les coûts à l'échange entre la Bretagne et le reste de la France, on suppose:
-$Contiguité = 1$
-$Langue = 1$
-$Colonie = 0$
-Distance simple $dist = 308.50$: il s'agit de la distance à vol d'oiseau entre Rennes et Paris
-Distance pondérée $distw = 522.80707$
-$ln(distw) = log(522.81)$
-Droits de douanes: $tariff = 0$ et $ln(tariff) = 0$
-Distances MNT: $dist_MNT^{A\&B} = dist_MNT^{C} = dist_MNT^{E} = 0$

5. Prédiction des flux entre la Bretagne et la France.

Pour reconstituer les flux entre la Bretagne et le reste de la France, il est nécessaire de renseigner les caractéristiques de la Bretagne, *i.e.* le Produit Intérieur Brut (PIB) breton. Pour cela, on part du PIB régional donné par l'INSEE [34], et on calcule son poids dans le PIB français, puis on applique le même % au PIB français donné par BACI en dollars. Le PIB du reste de la France est alors calculé en retirant le PIB de la Bretagne au PIB total de la France. Les chiffres données par l'INSEE sont les suivants:

34. https://www.insee.fr/fr/statistiques/2012723

- 2012: 86,154 milliards euros soit 4.13% du PIB national
- 2013: 87,600 milliards euros soit 4.14% du PIB national
- 2014: 89,654 milliards euros soit 4.17% du PIB national
- 2015: 91,910 milliards euros soit 4.19% du PIB national

Les chiffres de PIB régional diffèrent légèrement selon les sources. Selon la CCI (Chambre de Commerce et d'Industrie), le PIB de la Bretagne est de 88.3 milliards d'euros en 2015 soit 4.3 % du PIB national (8ème rang national) [35]. Selon l'INSEE [36], le PIB de la Bretagne est de 91,9 milliards d'euros en 2015 (soit environ 4.2 % du PIB national).

6. Reconstitution des flux inter- et intra-régionaux.
On utilise les estimations des effets fixes pays-années et les paramètres pour reconstituer les flux manquants, groupe par groupe (pour les 16 groupes). Nous appliquons un traitement particulier pour deux groupes: les produits laitiers, pour lesquels on remplace la valeur v par la moyenne sur ij quand la valeur est manquante ou nulle. L'autre groupe est le vin, pour lequel le Honduras exporte seulement aux États-Unis et seulement en 2014. Pour ce pays on suppose une petite valeur exportée à l'Arabie Saoudite, afin que l'on puisse utiliser le modèle de gravité.

7. Scénarios.
Nous reprenons les 5 scénarios de Cheptea et al. (2020) (*i.e.* le Chapitre II de la présente thèse).

8. Simulation en équilibre général, modèle de gravité structurelle.
Nous simulons les 5 scénarios pour les 16 groupes, groupe par groupe avec effets fixes exportateur-année et importateur-année.

35. https://www.bretagne.cci.fr/economie-et-territoires/chiffres-cles/richesses-et-pib-en-bretagne
36. https://www.insee.fr/fr/statistiques/2012723

Annexe C – Structure des groupes de produits

Dans cette annexe nous présentons la correspondance que nous avons choisie entre les codes produits de la nomenclature CPF4 et les groupes de produits agro-alimentaires utilisés dans notre étude.

Tableau C1: Répartition des codes CPF4 0111 à 0300 par groupes de produits

Code CPF4	Libellé	Groupe
0111	Céréales (à l'exclusion du riz), légumineuses et oléagineux	Céréales et produits céréaliers
0112	Riz, non décortiqué	Céréales et produits céréaliers
0113	Légumes et melons, racines et tubercules	Fruits et légumes
0114	Cannes à sucre	Café, épices, cacao, sucre
0115	Tabac brut	Tabac
0116	Plantes textiles	Autres produits
0119	Autres cultures non permanentes	Autres produits
0121	Raisin	Fruits et légumes
0122	Fruits tropicaux et subtropicaux	Fruits et légumes
0123	Agrumes	Fruits et légumes
0124	Fruits à pépins et à noyau	Fruits et légumes
0125	Autres fruits d'arbres ou d'arbustes et fruits à coque	Fruits et légumes
0126	Fruits et légumes oléagineux	Fruits et légumes
0127	Plantes à boissons	Café, épices, cacao, sucre
0128	Plantes à épices, aromatiques, médicinales et pharmaceutiques	Café, épices, cacao, sucre
0129	Autres cultures permanentes	Autres produits
0130	Plants: plants de pépinière, bulbes, tubercules et rhizomes, boutures et greffons; blanc de champignon	Autres produits
0141	Vaches laitières, vivantes et lait de vache, brut	Animaux vivants et produits animaux
0142	Autres bovins et buffles, vivants et leur sperme	Animaux vivants et produits animaux
0143	Chevaux et autres équidés, vivants	Animaux vivants et produits animaux
0145	Ovins et caprins, vivants; lait de brebis et de chèvre brut, laine en suint et poils d'ovins et de caprins	Animaux vivants et produits animaux
0146	Porcins, vivants	Animaux vivants et produits animaux
0147	Volailles vivantes et oeufs	Animaux vivants et produits animaux
0149	Autres animaux d'elevage et produits d'origine animale	Animaux vivants et produits animaux
0210	Arbres forestiers et services des pépinières	Autres produits
0220	Bois brut	Autres produits
0230	Autres produits forestiers	Autres produits
0300	Produits de la pêche et de l'aquaculture; services de soutien à la pêche	Poisson et produits de la mer

Tableau C2: Répartition des codes CPF4 1011 à 1200 par groupes de produits

Code CPF4	Libellé	Groupe
1011	Viandes de boucherie et produits d'abattage	Viande et produits carnés
1012	Viandes de volailles	Viande et produits carnés
1013	Produits à base de viande	Viande et produits carnés
1020	Préparations et conserves à base de poisson et de produits de la pêche	Poisson et produits de la mer
1031	Préparations et conserves à base de pommes de terre	Autres préparations de fruits et légumes
1032	Jus de fruits et légumes	Fruits et légumes
1039	Autres préparations et conserves à base de fruits et légumes	Autres préparations de fruits et légumes
1041	Huiles et graisses	Huile et graisses
1042	Margarines et graisses comestibles similaires	Huile et graisses
1051	Produits laitiers et fromages	Produits laitiers
1052	Glaces et sorbets	Produits laitiers
1061	Produits du travail des grains	Céréales et produits céréaliers
1062	Produits amylacés	Produits du travail du grain
1071	Pain ; pâtisseries et viennoiseries fraîches	Céréales et produits céréaliers
1072	Biscottes et biscuits ; pâtisseries de conservation	Céréales et produits céréaliers
1073	Pâtes alimentaires	Céréales et produits céréaliers
1081	Sucre	Café, épices, cacao, sucre
1082	Cacao, chocolat et produits de confiserie	Café, épices, cacao, sucre
1083	Café et thé transformés	Café, épices, cacao, sucre
1084	Condiments et assaisonnements	Café, épices, cacao, sucre
1085	Plats préparés	Autres préparations
1086	Aliments homogénéisés et diététiques	Autres préparations
1089	Autres produits alimentaires n.c.a.	Autres préparations
1091	Aliments pour animaux de ferme	Autres préparations
1092	Aliments pour animaux de compagnie	Autres préparations
1101	Boissons alcoolisées distillées	Autres boissons alcoolisées
1102	Vins de raisin	Vins
1103	Cidre et autres vins de fruits	Autres boissons alcoolisées
1104	Autres boissons fermentées non distillées	Vins
1105	Bière	Autres boissons alcoolisées
1106	Malt	Produits du travail du grain
1107	Boissons rafraîchissantes ; eaux minérales et autres eaux en bouteille	Boissons non alcoolisées
1200	Produits à base de tabac	Tabac

Chapter IV

From UK land-bridge to sea route: Irish agri-food exports to the EU, transport modes and Brexit [1]

1. A version of this chapter co-authored with Ole Boysen was presented at ETSG 2019 in Bern, Switzerland.

1 Introduction

United Kingdom's (UK) decision to leave the European Union (EU) in June 2016 raises many questions on future trade relationships between partners. The impact of Brexit on trade between the UK and the EU will depend on the nature of trade relationship to be negotiated, but introduction of new frictions will reduce trade relatively to the *status quo*, *i.e.* the UK remaining an EU Member State (MS). Brexit will affect not only the UK trade, but also that of countries such as the Republic of Ireland with the mainland EU, one of Ireland major partners in agri-food trade. Studies show Ireland will be most affected EU27 MS, particularly in agri-food sector (Keogh, 2018; Copenhagen Economics, 2018; Bellora et al., 2017). However, most of the studies do not take into account the specific features of Ireland's geography. Even if both road and maritime transports are available for Irish exports to the mainland EU, a substantial share transits the UK by road, the so-called UK land-bridge (in blue in Figure 1), since it provides the fastest access route. As the UK is part of the EU's single market, such transit transport through the UK is currently not subject to additional administrative or border costs. The UK can be seen as a transit country for the Ireland-EU27 trade.

Because of additional costs of using the land-bridge, Brexit will not only affect trade between Ireland and the UK, but also between Ireland and the remaining EU members. For example, additional costs include: the fact that Irish goods will have to use transit procedure which involves more administration and less flexibility in transport of goods; Irish hauliers will not be able to use cabotage in the UK which will raise their unit costs; additional customs delays or new requirements for the part of Irish trade utilizing the land-bridge, *etc*.

Even if direct shipping routes to continental ports could provide potential alternative routes for traders who currently rely on the land-bridge, [2] the transit time would be a lot higher. Relative low transit time is one of the main reasons for the use of the land-bridge. It represents less than 20 hours of travel, against up to 40 (for sea Roll-on/Roll-off operating systems – or RoRo) or 60 hours (sea Lift-on/Lift-off operating systems – or LoLo) (Breen et al., 2018). Figure 2 presents the transport times associated to the different modes. Frequency is another reason. For example, the busiest route linking Ireland and Britain is Dublin to Holyhead in north Wales and up to 10 ferry a day are linking them, in just two or three hours. Even if tariffs are avoided in the Brexit rupture, customs checks on both sides of the Channel could add hours to transit times for Irish truckers, in addition to the other direct costs. [3] Due to these additional costs, some exporters could shift to another transport mode, mainly the maritime one in agri-food trade. The exporter can either bear the extra road freight cost and sticks to the road mode, either shift to the alternative mode (maritime)

2. https://www.gov.ie/en/publication/d0334c-transport-and-logistics
3. https://www.politico.eu

which lengthens the distance and transport time (delay), or else, the two previous options are too costly and the exporter quits the market.

For Ireland, the land-bridge effect could be on top of any additional trade frictions introduced by Brexit, depending of the *"hardness"* of Brexit, *e.g.* sanitary and phyto-sanitary (SPS) checks if the UK leaves the single market, or border checks if the UK leaves the customs union. The land-bridge issue is particularly significant for the agri-food products. One of the reasons is that time sensitivity is substantial in this sector: high perishability of these goods, but also for example the just-in-time delivery requirements of supermarkets which do not have large storage space and require shelves to be filled on next day basis. This last point is the big saving of the land-bridge relative to direct sea routes. Short transport times and just-in-time delivery are of particular importance for perishable products like meat and dairy, which amount to 61% of total Irish agri-food exports.[4] Because of their major relevance in the Irish case, neglecting these transport cost changes might lead to a strong underestimation of Brexit trade impacts.

The aim of the study is to quantify the magnitude of potential Brexit consequences on Irish trade *via* the future land-bridge additional cost. We believe the previous studies failed to incorporate the higher cost of the using of the land-bridge route through the UK, which may have led them to underestimate the likely size of Brexit impacts on Irish exports. We would like to test this hypothesis, which corresponds to taking additional land-bridge costs into account in the estimation of the impacts of Brexit on trade. For this extra cost, the illustration of Irish exports to France is a good illustration. In order to quantify the variation in Irish agri-food exports to France in terms of modal shares and total value following an exogenous increase in the road transport costs (UK land-bridge) caused by Brexit, precise data are needed, namely the transport cost by mode and modal shares for each flow, at a disaggregated level, for at least intra EU trade. As these data are not available, an ancillary purpose consists in estimating transport costs, including the time cost, and modal shares determinants on the subsample we have, and predict them for the intra EU trade. We also need to estimate the modal substitution effects (or modal report) for different product groups. This will provide information on modal transport costs and the likely response of exporters in terms of shifting modes. Focusing on the land-bridge case, the constructed database provides all the mandatory information to address the first question, *i.e.* infer counterfactual potential additional transport costs for the use of land-bridge, and its effect on modal shares and finally the bilateral trade.

The remainder of the paper is structured as follows. In Section 2 we describe the Irish agri-food trade and how and why Ireland is particularly exposed to Brexit. We propose a literature review in Section 3 about transport in international trade. Section 4 presents the

4. Comext data for 2015, with authors' calculation.

Figure 1: Irish exports routes to the EU

Source: Copenhagen Economics (2018)

Figure 2: Irish exports routes and travel times to the EU

Source: Politico Research
*38 hours at least

data and methodology we use to build the tailored database, using models from literature, and results. In Sections 5 and 6 we present respectively the freight costs and modal shares estimation and prediction. Section 7 presents the focus on the Irish case and the model used to address the initial question. In Section 8 we discuss and conclude.

2 Irish external trade and exposure to Brexit via the UK land-bridge

Ireland's specificities make it a unique case. Due to its high trade intensity with the UK, its strong integration of production system and supply chains with the UK economy, and the fact that it does not share a land border with other EU countries, Ireland trade exposure is particularly high, both for trade with the UK and with the rest of the EU (Copenhagen Economics, 2018). Figure 3 presents the main Irish trade partners (for the year 2015). The UK is the first (6.3 billion euros), followed by the United States of America (USA – 1.2 billion euros), Germany and France (0.9 billion euros each). The special case of Ireland's high exposure to Brexit has recently been the subject of literature, especially concerning the trade between the UK and Ireland (Copenhagen Economics, 2018; Matthews, 2017a; Keogh, 2018; Arriola et al., 2018). Less discussed is the issue of the UK land-bridge and its potential implications on trade between Ireland and the rest of the EU (Breen et al., 2018; Kirby, 2017; Lawless and Morgenroth, 2017; Byrne et al., 2018; Copenhagen Economics, 2018).

Even if both road and maritime transport are options for Irish exports to the mainland EU, a substantial share transits the UK by road via the land-bridge since this provides the fastest access route.[5] Figure 4 shows that Irish agri-food exports are dominated by dairy and meat products. They account for 61% of total Irish agri-food exports.[6] As short transport times are of particular importance for perishable products like meat and dairy, the access to the land-bridge route is an important stake for the Irish agri-food trade.

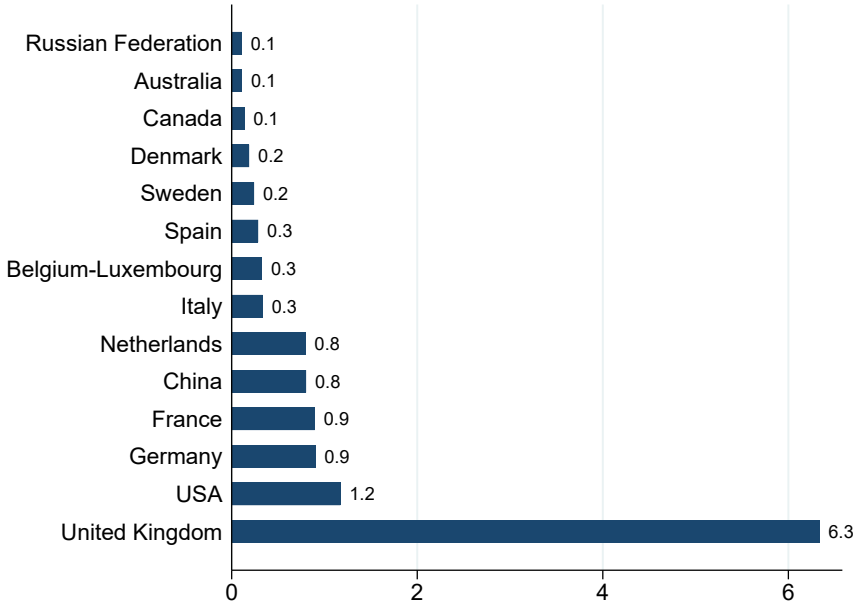
In order to study the sensitivity and exposure of Irish agri-food exports with a focus on transports, we aim to investigate the mode patterns and associated costs, at the most disaggregated level possible. But detailed transport mode data are rare, incomplete or not available. Some papers find ways to reconstruct or extrapolate data to obtain transport modes or transport costs, such as Gaulier et al. (2008) or Lawless and Morgenroth (2017). The latter examines the Irish agri-food transport and transport modes patterns, using the Central Statistics Office (CSO)[7] micro data on quantities transported from major Irish

5. Even if the merchandises have to leave Ireland by boat to UK before the road transportation, this kind of path remains shorter than direct sea transportation. In addition, through this path, the EU access is faster/easier.

6. Comext data for 2015, with authors calculation.

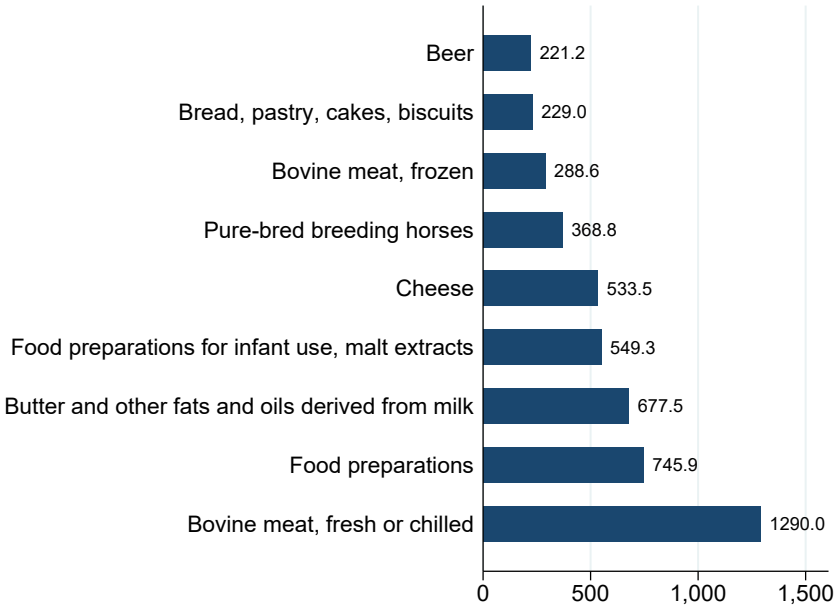
7. Central Statistics Office, `https://www.cso.ie/en/index.html`, viewed on May 2019

Figure 3: Irish agri-food main importers (2015, € billion)



Source: Comext

Figure 4: Main Irish agri-food exports categories to the EU (2015, € million)



Source: Comext

ports. They find a land-bridge use around 53% for exports and 11% as an import route, in volume. Since the port freight data are at a much aggregated level, they cannot differentiate at a product or even group level. We aim to fill this gap and build the mode shares at a more disaggregated level, knowing that the choice of the transport route depends, among others, on the type of good, in particular its time-sensitivity.

Trade represents only one aspect of the costs of Brexit for Ireland. These latter have been studied in the literature, such as foreign direct investment (FDI), gross domestic product (GDP), or welfare. According to Bisciari (2019) the biggest GDP and welfare losses after Brexit are expected for Ireland, Malta and the UK. The possibility of the return of a hard border with Northern Ireland (NI) is also at the heart of the cost of Brexit for Ireland. These aspects are out of our scope.

3 Transport in international trade: costs, modes, competition

In international trade literature, we know for sure that distance has a negative impact on trade (Marcias, 2015). Various empirical ways are used in the literature to estimate this impact, gravity being the main method used, since Tinbergen (1962). In gravity models, distance is the common way to proxy transport costs, following the iceberg assumption (Anderson and Van Wincoop, 2004 and death of distance). The average elasticity of trade to distance amounts to -0.9 (+10% in distance results in -9% in trade), according to Disdier and Head (2008), based on numerous papers estimating this value.

Yet, the distance approximation for transport costs has some limits. First, transport costs can differ greatly across the different modes and products considered. Second, the time cost is usually put aside or considered as included in the distance variable. The mode choice and the time cost are strongly linked, and the flows corresponding to each transport mode result from the choice of a transport mode made by firms. This choice is the result of a tradeoff between time and the cost of transport, for each product, according to Hummels and Schaur (2013). Even though one usually consider only the total value, all modes confounded, we believe the transport modes, but also the costs and time associated to each mode, need to be considered in trade analyses.

In this field, some papers studied intermodal competition or choice and the key parameters determining the use of diverse transport modes (*e.g.* García-Menéndez et al., 2004). The main determinant is obviously the cost. It can include many elements, such as insurance, fuel consumption, oil price, but also time (delay) or transshipment. Based on these costs, transport mode utilization elasticities can be calculated. For instance, Clark et al. (2004) found a 1.5% rise of maritime transport costs for a 10% increase in distance. Hummels and

Schaur (2013) model the firms's choice between exports using fast but expensive air cargo or slow but cheap ocean cargo. The infrastructure quality of both exporter and importer countries is also taken into account in some studies, *e.g.* Nordås and Piermartini (2004). While the perimeter of the transport costs does not reach consensus, traditionally the difference between *"Cost, Insurance, and Freight"* (CIF) value and *"Free On Board"* (FOB) value is used as a proxy for transport costs. This is an indirect way to obtain transport costs. We observe there is no consensus or database giving the time or time cost associated to modes, at a disaggregated level (ad-valorem equivalent –AVE– of the FOB value for example). Oberhofer et al. (2018) review the literature around the impacts of time on trade. Some papers in the literature study the effect of transport costs variation on a specific mode, but leave aside the subtitutability between modes, *e.g.* Korinek and Sourdin (2009).

Direct data of transport costs remain scarce or even non existant for some sets of countries or products, including the CIF and FOB data. More precisely, the proxy consists in the differences between mirrored flows (imports CIF and exports FOB), generally drawing on United Nations (UN) Comtrade data, to implicitly derive transport costs. According to Hummels (2007), the best data for evaluating the ad-valorem impact of transportation costs over time comes from a few importers such as New Zealand and the United States that collect freight expenditures as part of their import customs declarations, and publish them in statistical offices (Hummels et al., 2014; Hummels, 2001a).

To better understand the transport cost determinants, estimations have been run in many studies. Based on estimations, some authors even created databases. For instance, Miao and Fortanier (2017) propose the International Transport and Insurance Costs (ITIC) database. This OECD [8] study estimates transport costs using gravity, but they are not differenciated by transport modes. They release the estimated CIF FOB margin, in % of import value in FOB. Gaulier et al. (2008) intended to compute such a database, using a gravity approach with flows from UN Comtrade, and explanatory variables including distance, distance squared, contiguity, landlockedness and the median unit value of each product (to account for higher costs of trading heavier commodities).

Tables 1 and 2 present the literature concerning the analysis of transport costs determinants and their impacts on trade. More precisely, we are interested in explanatory variables used in determining the freight costs, as a wide set is used, namely, *e.g.*, the geography (distance, landlockedness, island status), the product unit value, or the infrastructure quality.

8. Organisation for Economic Co-operation and Development, http://www.oecd.org

Table 1: Literature review: transport costs determinants and impacts on trade

Study	Method	Sample	Variables	Results
Hummels (2003)	Regression of ocean and air freight rates, with commodity fixed effects.	United States (1974-1996) and New Zealand (1965-1997), customs reports. CIF-FOB values of shipping costs.	Dep variable: ad-valorem freight rate from exporter j, port p, commodity k, time t. Expl variables: distance, unit value.	The effects of the different explanatory variables on transport costs differ grealy across the modes, ocean being less sensitive to distance and unit value.
Limao and Venables (2001)	Regression of ln(AVTC) = ln(CIF/FOB).	Trade data, from Baltimore to the world (64 destination cities).	Dep variable: transport costs (and trade). Expl variables: log(distance), common border, land-locked, islands, infrastructure, GDP per capita.	+ 1000 km causes a 190$ of rise for maritime transport and 1380$ for road transport. Particular importance for land-locked countries.
Hummels (2001a)	Regression of freight rates for air and ocean shipping.	Dataset including prices, quantities, and speed for different transportation modes in USA trade. 2-digit Standard International Trade Classification (SITC) category.	Expl variables: weight and value of the shipment, distance.	Manufactured goods: +1 day in ocean transit time is worth an average of 0.8% of the value of the good /day, equiv. to a 16% tariff for the average length ocean shipment. +1 day reduces the probability of trade by 1% (all goods) to 1.5% (manufactures). Tax equivalent of the time cost: 9% (for USA in 1998).
Byrne et al. (2018)	Increase of NTM as border waiting time (all goods, not agri-food specific) with diffference gravity specification.	2013 to 2015. Import custom data. Ireland-UK.	Dep variable: trade. Expl variables: border waiting time.	+11h of delay if products are imported from a port instead of a land border. 9.6% decline in trade flows between the UK and Ireland from an increase in border waiting times. Heterogeneity in the exposure across different types of goods.
Oberhofer et al. (2018)	Structural gravity model. Effect of time on trade. Full endowment general equilibrium with CPPML.	2006 to 2012, 63 countries.	Dep variable: trade (and welfare). Expl variables: geometric mean of time to import and to export.	Significant negative effect of the time required for border procedures that is driven by the time needed for document preparation. +1 day in transit is equivalent to AVE tariffs of 0.82 percentage point (not mode specific).
Imbs and Mejean (2017)	Measure of aggregate trade elasticity, relying on the equivalence of welfare gains from trade and price elasticities. The theoretical aggregate trade elasticity is defined as the value that equals the welfare gains. Price elaqsticities are estimated for each International Standard Industrial Classification (ISIC) sector (three-digit ISIC (revision 2) of each importing country.	CEPII-BACI database (trade and unit values) at sector level. HS6 level, around 5000 products and a large cross-section of countries. Aggregation in 27 sectors. 1995 to 2004.	Sectoral elacticities estimation via a structural equilibrium model of bilateral trade. Prices, bilateral trade CEPII-BACI database.	Provide trade elasticity estimates, 3-digit levels for 28 countries (price elasticities for imported quantities, aggregated agri-food sector). Elasticity values vary greatly accross countries.

Table 2: Literature review: transport costs determinants and impacts on trade

Study	Method	Sample	Variables	Results
Hummels and Schaur (2013)	Modal choice decisions of firms engaged in trade using the trade-off between fast and expensive air transport versus slow and inexpen- sive ocean shipping ; identification of the value of time saving (consumers' willingness to pay fo time savings).	Data from the US Imports of Merchandise database, 1991-2005.	Dep variable: Firms revenue. Expl variables: Time, origin and delivered prices, and ad- valorem shipping costs.	+1 day in transit is equivalent to an AVE tariff of 0.6 to 2.1%. The most time-sensitive trade flows involve parts and components trade (they have a time sentitivity 60% higher than other goods).
Anderson and Van Wincoop (2004)	Review of the methods for measuring the trade costs.	x	x	Better measurement of trade costs is highly desirable. The quality of the existing measures is low and can be improved. Direct measures of policy barriers are scandalously difficult to find and to use, es. Transport-cost data could relatively easily be improved greatly.
Harrigan and Venables (2006)	Models in a particular framework that enables to assess the profitability of clustering activities together (spatial concentration of activity).	x	x	Time costs are qualitatively different from direct monetary costs such as freight charges, because of uncertainty. Timeliness is not only a quantitatively important aspect of proximity, but also matters qualitatively, creating an incentive for clustering of activities. Importance of the just-in-time delivery.
Keogh (2018)	Effects of Brexit (soft or hard) on Irish good via a structural gravity model in partial equilibrium with PPML.	CSO's internal trade file at 8-digit Combined Nomenclature (CN) level: value and volume of Irish goods export items by country, date and type. Panel 1994 to 2016.	Dep variable: Irish exports. Expl. variables: traditional gravity variables (CEPII gravity set), except contiguity because of colinearity with the dummy *"Northern Ireland border"*.	1% increase in trade costs will result in a fall of 0.73% in goods exports value overall. Soft Brexit: No effect on trade. Hard Brexit: trade with EU-28 will fall by 1.4% while the overall value of goods exports will fall by € 0.8bn on average.
Hummels (2007)	Characterization of the patterns of international ocean and air transportation costs. Estimation of the determinants of transportation costs.	US Imports of Merchandise data for 1974–2004, 5-digit SITC level.	Dep. variable: log of ad valorem freight cost, for air and ocean. Expl. variables: unit value, distance, fuel costs, yearly trend, interaction between distance shipped and the yearly trend.	Transportation costs co-vary with distance and are larger and exhibit much greater variability across exporters than do tariffs.

4 Data and method: modelling freight costs and modal shares

In this section we first present the databases used in the analysis, followed by a summary of the different substeps of the tailored database construction. We select data from 2012 to 2015. Our data panel starts in 2012, after the effects of the 2008-2009 economic crisis were completely absorbed in most countries, and ends in 2015, the year before the Brexit referendum (2016). In addition, non-tariff measures (NTMs) data are not well documented before 2012.

4.1 Data

The International Transport and Insurance Costs (ITIC) from OECD is one of the most extensive transport costs database available. It contains the CIF FOB margins also called freight rates, or FR_{ijgt}, defined as follows:

$$FR_{ijgt} = \frac{CIF_{ijgt} - FOB_{ijgt}}{CIF_{ijgt}}$$

With i= exporter; j=importer; g=HS4 group of product (Harmonized System, 4-digits level); t=year. Table A1 in appendix presents the chapters names corresponding to each HS4 category. Freight rates are not differentiated by mode, and are aggregated at the HS4 level, contrary to the data used by Hummels et al. (2014). From these margins we compute the ad-valorem transport cost $(1 + AVTC_{ijgt})$, also used in Limao and Venables (2001), to obtain a more intuitive transport cost measure, AVE-like:

$$1 + AVTC_{ijgt} = -(\frac{1}{FR_{ijgt} - 1}) = \frac{CIF_{ijgt}}{FOB_{ijgt}} = \frac{FOB_{ijgt} + insurance\ and\ freight\ costs}{FOB_{ijgt}}$$

The Comext International Trade in Goods Statistics (ITGS) reports FOB export value and quantity data for each $ijktm$, with i the exporter; j the importer; k the HS6 product (Harmonized System, 6-digits level); t the year; m the transport mode by which products are leaving the territory of the export country but only from EU to non EU countries. The indicated transport mode does not necessarily correspond to the dominant transport mode used for this particular flow. This database also exists for intra EU trade but data are too incomplete to be workable. We assume the following hypotheses for the analysis: **(i)** Freight costs determinants are the same for EU to non EU exports than intra EU ones. **(ii)** The mode entered by ITGS is the main mode used. We restrict the dataset such that we have a high probability that the transport mode matches the dominant mode used: we remove some importers such as the USA, to keep only the Eurasian continent. The latter

have the choice between at least sea or road mode, while it's not the case for EU-USA flows for example (road mode is not available). We present the list of the shortlisted countries in appendix. We compute the unit value UV as the FOB average unit value (per ton) across all modes of transport from this database. The UV is therefore not mode specific. ITGS gives 8 transport modes. [9] We are only interested in the maritime and road ones.

The International Trade Database (BACI), from CEPII, [10] reports the bilateral trade flows at a very disaggregated level (HS6), in value and quantity. We select the 64 main trading countries, covering 75% of the global agri-food trade. The gravity set containing distances, contiguity, common language, common colonial relationship, and the simple distance (between most populated cities), considered as road distance, is from the gravity dataset of CEPII. [11] In this set, the main variables relating to trade costs are from GeoDist, the CEPII distance dataset. The CERDI [12] – seadistance database [13] contains bilateral maritime distances between 227 countries and territories. As we aim to differentiate road distance and sea distance, we include this dataset. Finally, the global crude oil price is a yearly index from the commodity prices and index by International Monetary Fund (IMF).

4.2 Method and summary of the modelling section

Even if transport costs have been widely studied in the international trade literature, direct data remain scarce, incomplete and hardly workable. [14] First, mode shares and mode specific freight costs are usually missing from databases. This lack of direct data can go with uncertainties and approximations in models using freight costs. In most of the case, they are approximated with the distance between two countries, and the transport mode is not taken into account. The approximation with the distance is not always satisfying, as transport costs can differ greatly across the different modes and products considered. For some countries, *e.g.* the USA example, as the freight costs and mode used are reported directly in the USA customs declarations, US freight costs are directly available, they don't have to be approximated by the distance. Unfortunately it is not the case for all countries. In particular, this kind of data is not reported in the EU customs. Second, the distance approximation covers not only the economic costs but also the time costs. This approximation is not mode specific and not precise enough as time differences can be pregnant. We precisely need freight costs, both economic and time related, and mode used for Irish exports. In a more general way, we aim to associate a freight cost and modal share

9. The 8 modes are: *"Unknown"*, *"Sea"*, *"Rail"*, *"Road"*, *"Air"*, *"Postal consignment"*, *"Fixed transport installations"*, *"Inland waterway transport"*, and *"Own propulsion"*.
10. Centre d'Etudes Prospectives et d'Informations Internationales
11. http://www.cepii.fr
12. Centre d'Etudes et de Recherches sur le Développement International
13. http://www.ferdi.fr
14. According to Anderson and Van Wincoop (2004): *"Better measurement of trade costs is highly desirable. The quality of the existing measures is low and can be improved. Direct measures of policy barriers are scandalously difficult to find and to use, considering the importance of trade policy in overall international policy making and to potential welfare-improving changes. Transport-cost data could relatively easily be improved greatly."*

to each trade flow, including the EU flows, and indeed, Ireland's exports. This constitutes the ancilliary purpose.

(i) The first substep is the **freight costs** estimation and prediction, detailed in section 5. We propose a methodology in the same spirit than the one used in Hummels et al. (2014) with the US data but for EU exporters, having the choice between road and maritime mode. We combine the ITGS database giving the quantity and value of exported goods and the transport mode used for EU exporters to non-EU importers, with the ITIC database, which contains the CIF FOB margins also called freight rates (FR_{ijgt}), not differentiated by mode. Using these two databases combination and literature models, we highlight the determinants of freight rates, estimate the corresponding coefficients, and predict the mode specific freight rates for each ITGS flow, *i.e.* for sea and road modes and for each exporter and importer, non only from EU to non EU. In the same time we also predict the mode specific freight rates for each BACI flow.

(ii) The second substep is the **modal shares** estimation and prediction, presented in Section 6. We use both the modal shares from ITGS and the previously calculated freight rates to determine the role of these freight rates on the modal shares and substitutability between modes, specifically road and maritime transport, in the EU exporters case. We also propose other explanatory variables in order to take into account other effects such as the time cost. Based on the estimated coefficients, we predict the mode shares for each BACI flow.

(iii) Based on estimations and predictions from (i) and (ii), each trade flow from BACI [15] database is coupled to a freight rate and modal shares, in Section 7. We obtain a tailored database containing bilateral trade (all modes confounded, direct data) from BACI and freight information. Transport modes and estimated transport costs (in % of the FOB trade value) are associated to each BACI quadruplet of HS6 product k, exporter country i, importer country j and year t – or $ijkt$ – flow. We use the new database in an applied example. We assess the effect of the change in sea and road modal shares (through the freight costs change) on Irish exports to the EU. We focus on agri-food only, which means the chapters 1 to 24 of the Harmonized System (HS).

Figures B1, B2 and B3 in appendix present a summary of the databases harmonization and handling for each of the three steps.

15. Basis for International Trade Analysis, bilateral trade flows from CEPII: http://www.cepii.fr

5 Freight costs: estimation strategy and prediction

5.1 Estimation and prediction strategy

Several options have been used in the literature to model freight costs. Following the method used by Hummels et al. (2014), we implement a two steps procedure, adapted to our case and our data. First they use US freight cost data to estimate the coefficients of the different determinants (by mode), the freight costs being directly reported in the custom data (CIF FOB value). They then use the estimates to construct the Danish freight costs, for each mode. As we use both mode-specific and not mode-specific databases we perform a slightly alternative method. As the BACI database is very precise and complete concerning the trade flows, but contains no information about transports, we aim to associate freight costs and modal shares to the BACI flows. To achieve this goal we need to use and combine other variables and databases, detailed above.

We aggregate the ITGS flows at a HS4 level (g) and keep only the monomode flows: maritime share = 1 or road share = 1, *i.e.* 100% sea or 100% road. We then obtain a subsample of singlemode flows and corresponding ad-valorem transport costs (AVTC). The boundary of this approach is the drastic restriction of the number of observations for the estimation: for maritime estimation we keep 57 162 observations and for road 27 736 over 150 869 non nul observations. On the other hand, this restriction allows to be sure that, for a given flow, AVTC correponds to only one mode (road or sea for example). Combining ITIC and ITGS, we associate a general freight rate (ITIC) to a monomode flow (ITGS), which means associate a freight rate to a $ijgtm$ flow, with m corresponding to a mode. More precisely, **(a)** we estimate the freight costs determinants for sea and road transports separately and **(b)** using the estimated coefficients (on the subsample of monomodes) we predict the mode specific freight costs for each ITGS flow (EU to non EU trade, at HS4 level) but also for each BACI flow (all countries, HS6 level).

For the part (a), we run the estimations of the equations (1) and (2). The estimations are based on single mode flows so we know the given AVTC is associated to only one mode. [16] The results of the OLS regression for each mode, at the agri-food sector level, are presented in Table 3. Other variables could be included, such as infrastructure quality, as it can explain 40% of transport costs for coastal countries and 60% for landlocked countries (Limao and Venables, 2001), time or delay, or GDP and GDP-per-capita, as in Gaulier et al. (2008), to account for economies of scale and for infrastructure and quality, respectively.

16. Estimations are run on a subset of exporters and importers from Comext ITIC database selected for the estimations and presented in appendix. We selected countries with trade access to both sea and road. In particular, we have excluded landlocked countries and islands.

$$\ln(AVTCsea_{ijgt}) = \alpha^s + \beta_1^s \ \ln(UV_{ijgt}) + \beta_2^s \ \ln(fuel_t) + \beta_3^s \ \ln(sea\ distance_{ij}) + \psi_g^s + \epsilon_{ijgt}^s \quad (1)$$

$$\ln(AVTCroad_{ijgt}) = \alpha^r + \beta_1^r \ \ln(UV_{ijgt}) + \beta_2^r \ \ln(fuel_t) + \beta_3^r \ \ln(distance_{ij}) + \psi_g^r + \epsilon_{ijgt}^r \quad (2)$$

With g the HS4 level product, $\ln(AVTCsea_{ijgt})$ and $\ln(AVTCroad_{ijgt})$ correspond to $\ln(AVTC_{ijgt})$, the average values across all modes of transport, from the OECD ITIC database. UV_{ijkt} (€/ ton) is the FOB average unit value (per ton) across all modes of transport from the ITGS Comext database. $Fuel_t$ is the global crude oil price index from International Monetary Fund (IMF). $\ln(distance_{ij})$ is the log of the distance (km) between the capitals of countries i and j. $\ln(sea\ distance_{ij})$ is the log of the sea distance (km) between the two major ports of countries i and j. ψ_g^s and ψ_g^r are the HS4 fixed effects. ϵ_{ijgt}^s and ϵ_{ijgt}^r are the error terms.

Table 3: ln(AVTC) by mode

	ln (AVTC) sea	ln (AVTC) road
ln(UV)	-0.017***	-0.031***
	(0.001)	(0.003)
ln(fuel)	0.145***	0.154***
	(0.002)	(0.010)
ln(seadistance)	0.045***	
	(0.001)	
ln(distance)		0.388***
		(0.003)
FE HS4	Yes	Yes
R-squared	0.780	0.544
Observations	57,162	27,736

Note: AVTC: Ad-valorem trade cost
Column title correponds to the explained variable
Significance levels: ***0.01 **0.05 *0.10

5.2 Results, comments and discussion

Concerning the robustness of the model, $\ln(fuel) * distance$ and $\ln(fuel) * sea\ distance$ have been considered as explanatory variables, because changes over time in fuel prices affect the level of costs, the relative cost of employing a mode *vs.* another and the relative cost of distant versus proximate partners. In addition, shocks to oil prices differentially affect costs depending on which mode is used and how far goods travel (Hummels et al., 2014). But in our specific case, as the coefficient was nul and does not impact significantly the other coefficients, we made the choice to dismiss them.

The unit values (UV) we use in the regressions are not mode specific. Even if the mode specific unit value would be more relevant for the transport cost of the mode, the mode-specific unit value is endogenous as it changes if traders change their choice between sea and road. Thus, the general unit value is more appropriate for this study.

Maritime freight rate is less sensitive to distance than road freight rate, while road rate is more sentitive to the fuel price than the sea mode. We also observe, consistently with the literature, that in both modes, if the UV is higher, the corresponding freight rate is lower. The latter is expressed as a proportion of the unit value. Therefore, for a same value of freight rate, if the product has a higher UV, the freight rate is automatically lower, *ceteris paribus*. In other words, transportation lowers the delivered price of high-quality (expensive) relative to low-quality (cheap) goods Hummels (2007). In addition, an increase in the UV leads to a more important drop to road freight costs, in comparison to sea freight cost. We then assume that high quality products (high UV) are preferably carried by road.

For the part (b), using the estimated coefficients and fixed effects of each mode, we predict the freight costs for each $ijgtm$ of Comext ITGS, *i.e.* the associated AVTC. We obtain a database with freight costs associated to each $ijgtm$ of Comext (EU to non-EU) but also of the BACI database. Here we focus on the ones predicted for Comext. The estimated maritime costs does not vary much: the set of predictive values are included in 2.06% and 3.82% of ad-valorem FOB value. On the contrary, the road freight costs are included in 7.99% and 122.69% of ad-valorem FOB value. If we restrain the sample to the intra EU trade the set of predictive values are included in 2.15% and 3.63% of ad-valorem FOB value for maritime freight costs, and in 7.99% and 57.55% of ad-valorem FOB value for the road freight costs.

In comparison, Hummels (2001b) shows the wide dispersion in freight rates over commodities and across countries in 1994. The all-commodities trade-weighted average transport cost from national customs data ranges from 3.8% of the FOB price for the US to 13.3% for Paraguay. Anderson and Van Wincoop (2004) use a representative full transport cost of 21%.

We observe that, for a given country pair, within a mode (sea or road), the freight costs variations are quite small, which means that the product dependant variable, namely the UV, does not count a lot in the AVTC value. Nevertheless, variations from a country pair to another are more important, especially in the case of road freight cost. For instance, the AVTC road for Ireland as exporter goes from 21.4 (destination: UK) to 70.0 (destination: Singapore) for the HS6 product 020130 (chapter: meat of bovine animals), which is one of the most exported Irish products.

Table 4: Average AVTC by importer-exporter-chapter: the case of Ireland as exporter and European importers for chapter 4 (dairy products)

Exporter name	Importer name	AVTC sea	AVTC road
Ireland	Austria	3.03	37.84
Ireland	Belgium-Luxembourg	2.89	28.84
Ireland	Bulgaria	2.97	43.07
Ireland	Czech Rep.	2.90	36.35
Ireland	Denmark	2.97	34.68
Ireland	Finland	3.01	41.61
Ireland	France	3.03	28.79
Ireland	Germany	2.89	30.47
Ireland	Greece	3.02	46.55
Ireland	Hungary	3.02	39.42
Ireland	Italy	3.04	40.46
Ireland	Latvia	3.02	41.34
Ireland	Lithuania	3.00	42.22
Ireland	Netherlands	2.80	27.64
Ireland	Nigeria	3.12	60.30
Ireland	Norway	2.89	34.00
Ireland	Poland	2.98	40.20
Ireland	Portugal	2.90	37.79
Ireland	Slovakia	3.06	38.66
Ireland	Spain	2.93	35.85
Ireland	Sweden	2.93	38.06
Ireland	Switzerland	2.96	32.75
Ireland	Turkey	3.09	47.84
Ireland	United Kingdom	2.83	23.62

Source: Computations by authors
Note: AVTC: Ad-valorem trade cost

As an illustration, Table 4 presents the average maritime and road AVTC for Ireland as exporter, European countries as importers, for the dairy products (chapter 4). Table 5 presents the average maritime and road AVTC for Ireland as exporter, France as importer, for the 24 chapters. At a more disaggregated level we observe more variation. In all cases, the road freight costs are much higher than the sea ones. Yet, the road mode is widely used. We assume the road choice bring other benefits than freight rate. According to Hummels and Schaur (2013), the choice between two modes represents a tradeoff between time and the cost of transport. In addition, according to Hummels (2007), consumers are sensitive to the delivered price of merchandise, not the transportation price. If transportation is a small fraction of the delivered price, then when choosing transport mode, the explicit costs of transportation may be trumped by implicit costs such as timeliness or reliability. Then, especially for a high value good (expensive), other aspects than the pure freight costs will be considered, such as the timeliness. Hence, for the modal share estimation and prediction, we believe time has to be included in the determinant.

Table 5: Average AVTC by importer-exporter-chapter: the case of Ireland as exporter and France as importer

Exporter name	Importer name	Chapter	AVTC sea	AVTC road
Ireland	France	1	3.00	28.26
Ireland	France	2	3.03	28.78
Ireland	France	3	3.00	28.29
Ireland	France	4	3.03	28.79
Ireland	France	5	3.01	28.79
Ireland	France	6	3.01	28.46
Ireland	France	7	3.02	28.80
Ireland	France	8	2.93	27.67
Ireland	France	9	2.96	27.52
Ireland	France	10	3.07	29.67
Ireland	France	11	3.05	29.10
Ireland	France	12	3.00	28.54
Ireland	France	13	2.94	27.41
Ireland	France	14	3.09	29.87
Ireland	France	15	3.01	28.45
Ireland	France	16	3.01	28.44
Ireland	France	17	2.98	28.14
Ireland	France	18	3.05	28.81
Ireland	France	19	3.04	28.94
Ireland	France	20	2.99	28.50
Ireland	France	21	3.00	28.22
Ireland	France	22	3.05	29.01
Ireland	France	23	3.13	30.41
Ireland	France	24	3.00	27.93

Source: Computations by authors

Note: AVTC: Ad-valorem trade cost

6 Modal shares: estimation strategy and prediction

6.1 Estimation and prediction strategy

In this section, we estimate the impact of some trade costs on the volume of exports, for each transport mode. More precisely, we are interested in the mode shares variation, *i.e.* the volume variation using a specific mode relatively to another mode (namely sea and road modes). For the estimation, we use the ITGS Comext database augmented with the predicted modal freight costs ($AVTCroad$ and $AVTCsea$), at HS4 level.[17] More precisely, **(a)** we estimate the modal shares determinants for bimodal flows; **(b)** using the estimated coefficients (on the subsample of bimodal flows) we predict the modal shares for each BACI flow (all countries, HS6 level) and **(c)** we focus on the marginal effects of some of the explanatory variables. Section 6.2 presents the multinomial fractional logit (MFL) theory, and Section 6.3 the results, comments and discussion.

We impose some restrictions and hypotheses:

- We keep the bimodal flows only, from EU to non EU countries, *i.e.* the combinations $ijgt$ using both road and maritime modes, leaving the EU to a non EU country. Concerning agri-food Irish exports, the road and maritime mode are almost exclusively used (Lawless and Morgenroth, 2017). We restrain the sample to get closer to these conditions as, *in fine*, we are interested in this case.
- Since shares are not independant from one to another, a simple OLS cannot be used.
- Unit values, fuel price and simple distances being already used in the freight costs estimations, we exclude them from shares estimations.

6.2 Multinomial fractional logit

Theory

For the modal shares estimation, although a seemingly unrelated regression (SUR) would be an alternative relevant option, we prefer the multinomial fractional logit (MFL), following Marcias (2015). The MFL methodology was developed among others by Papke and Wooldridge (1996) and an extension of it by Mullahy (2015) and Sivakumar and Bhat (2002). With this method we perform the estimation of shares between 0 and 1, with the sum equals 1. The MFL models use quasi-maximum likelihood estimations.

The dependant variable is the share of the exported quantity of group g transported from country i to country j the year t by a mode m (s_{ijgtm} with $m = 1, 2$). $s_{ijgtm} \in [0;1]$ and $\sum_{j=1}^{2} s_{ijgtm} = 1$. The esperance of s_{ijgtm} is given by $E[s_{ijgtm}|z_{ijgt}] = G_m(z_{ijgt}B)$ with $G(.)$ a known function that respects $0 < G(.) < 1$ so that the values of s_{ijgtm} is in the interval $[0;1]$,

17. Estimations are run on a the same subset of exporters and importers from Comext ITIC database than for the freight cost estimation.

we have z_{ijgt} a vector of the explaining variables and the matrix B gathers the estimated coefficients. Here $G(.)$ is assumed to take a multinomial logit form. Then we have:

$$E[s_{ijgtm}|z_{ijgt}] = G_m(z_{ijgt}B) = \frac{\exp(z_{ijgt}B_m)}{\sum_{l=1}^{2}\exp(z_{ijgt}B_l)} \tag{3}$$

The multinomial quasi-likelihood function is defined as:

$$Q(\beta) = \pi_{j=1}^{J}\pi_{k=1}^{K}G_m(z_{ijgt}B)^{s_{ijgtm}} \tag{4}$$

The estimates corresponding to the maximization of $Q(\beta)$, for the two modes subsample, are presented in Table 6, with the coefficients for road set at zero. The model used fits by quasi maximum likelihood a fractional multinomial logit model. Each dependant variable ranges between 0 and 1 and all dependant variables (proportions, shares) must add up to 1 for each observation. It is a multivariate generalization of the fractional logit model proposed by Papke and Wooldridge (1996).

Explanatory variables

As we do not find any studies using AVTCs as inputs in modal shares estimations using MFL, for the choice of explanatory variables, we follow Miao and Fortanier (2017) and Gaulier et al. (2008) even if they are not interested in the modal shares but more generally in the freight costs determinants and their relationship.

We are interested in testing for a general relationship between mode shares, transport rates, time costs, and geographical distance. The traditional gravity variables (contiguity, common colonial past and common language dummies) are included, along with the AVTC ratio between road and sea. Assuming time cost and geographical distance are strongly linked, we add the ratio of sea distance over road distance, and the squared same ratio. Distance ratio and squared distance ratio are here considered as proxys for time costs.

The transport costs ratio, distances but also contiguity are directly related to transport while it is indirectly the case for language and colony variables. As a matter of fact, the latter are more related to networks. Networks grease the wheels of trading goods and thus transporting those goods. In fact, one can imagine transport networks to be more developed between countries with higher propensity to communicate due to common historical links (Gaulier et al., 2008). With the colony and common language variables we are then capturing bilateral transportation networks and test what are their influence on the modal shares, if they have any.

Substitutability and marginal effect

Finally, in this step we are interested in the marginal effects of some of the explanatory variables on the modal shares. Calculating partial effects for limited dependent variables

can be tricky, especially for multinomial logit models. The coefficients obtained in the regression model represent the logit-transformed odds ratio for that specific choice against the baseline choice. This is not intuitive in terms of actual effects on that specific choice. The coefficients and standard errors obtained in the original models are not the basis for evaluating hypotheses.

Instead, we need to compute the *"partial effects"*, as we usually do in linear models. However, the partial effect in logit-type models is thorny because the effects are heterogeneous across different observations. In other word, each unique observation have a different set of partial effects. The marginal effect represents how a unit change in one variable changes the value in a certain choice. Typically, two types of aggregation measures are used to illustrate the global partial effects: one is the partial effects at the mean, which is the partial effect of then variable when every other variables are set at their mean; and the other is partial effect of the average, which is the average of partial effect for all observations. [18]

With the marginal effect related to the MFL model we can quantify the potential substitution occuring between the two modes (maritime and road), considering a constant quantity traded, in response to a change in ratio of the AVTC of each mode, and proxies for the time, at both the agri-food sector level and chapter level. We assume that the substitutability is linked to the mode specific AVTC and the time-sensitivity, which can also be formulated by a trade off between costs and time.

6.3 Results, comments and discussion

Concerning **(a)** the estimation, Table 6 gives the MFL coefficients at the aggregated level (agri-food sector). Road is taken as reference and then is not presented in the table, *i.e.* the coefficient for road is set at zero. Tables C1, C2 and C3 in appendix give the results run chapter by chapter. All explanatory variables are higly significant at the agri-food level, while it is not the case for all chapters. We observe AVTC ratios and colony variables are always higly significant, for all chapters. Using the estimated coefficients (on the subsample of bimodal flows) we predict **(b)** the modal shares (sea share and road share) for each BACI flow. Selected results concerning Irish exports are presented in Section 7.

Table 7 gives **(c)** the marginal effects at the mean sample point, for the agri-food sector and the variables of interest, namely the AVTC ratio, distance ratio and squared distance ratio. We are highly interested in this marginal effect for our problematic of substitutability. We observe, as expected, that the increase of road freight rate over sea freight costs decreases the road share. A one unit increase in the ratio of the AVTC (*e.g.* the road freight costs double) makes the share of road fall of approximately 4%, at the mean sample point (at the aggregated agri-food level). As the sea distance over road distance ratios decreases (*i.e.*

18. https://github.com/f1kidd/fmlogit

road route time is increasing), we observe two opposite effects: a decrease in road share (6.9% for a one unit increase in the distances ratio) and an smaller increase (0.3% for a one unit increase in the squared distances ratio). A conceivable explanation is that a modal report from road to sea will generate a higher activity in the maritime route. This activity can increase congestion and, as a consequence, time costs. This, in turn may also raise final transport costs and hence have a negative effect on the sea share.

Tables C4, C5 and C6 present the marginal effects at the mean sample point, at chapter level. For all chapters, the directions of the AVTC ratios effect are the same at chapter level, *i.e.* a positive impact. In most of the cases, the distances and square distances ratios have the same effect than at the aggregated level, but some chapters are exceptions (namely 1, 4, 6, 8, 13, 14, 16, 18, 19, and 22). We assume the time costs have differenciated impacts in function of the products (at chapter level) characteristics, particularly their perishability. For instance, for the chapters 6 (live trees and other plants) and 14 (vegetable plaiting materials), if the road time cost increases, the sea share slightly decrease, which can be counter intuitive. But we can assume that other considerations are at stake for these products, making the road transportation essential. [19] In this case, time costs does not count a lot, contrary to meat for example. This is why we do not observe a massive modal report from road to sea.

The highest reports to the sea (effect of the distances ratio) are observed for the groups 3 (fish and crustaceans) and 10 (cereals). According to our hypothesis, we conclude that these products are particularly sensitive to the time cost.

19. For instance, the cut flowers distribution circuit in the UK and Ireland does not have a well-defined structure like other European countries. Thus an importer sells directly to supermarkets. This eliminates the classic distribution chain. A credible assumption is that it's not possible to export important quantities at the same time (containers), so the road is preferred.

Table 6: Multinomial fractional logit, agri-food sector

	Sea share
AVTC road / AVTC sea	0.322***
	(0.003)
Contiguity	-1.947***
	(0.070)
Colony	-3.494***
	(0.208)
Common language	0.986***
	(0.033)
distance sea / distance road	-0.557***
	(0.021)
(distance sea / distance road)^2	0.026***
	(0.003)
Constant	-3.430***
	(0.045)
Observations	1.01e+05

Note: AVTC: Ad-valorem trade cost
Column title correponds to the explained variable
Significance levels: ***0.01 **0.05 *0.10

Table 7: Marginal effects of the multinomial fractional logit, agri-food sector

	Road share	Sea share
AVTC road/AVTC sea	-0.0401017	0.0401017
distance sea / distance road	0.0694397	-0.0694397
(distance sea / distance road)^2	-0.0032432	0.0032432

Note: AVTC: Ad-valorem trade cost

7 Illustration: Brexit impacts on Irish exports using a standard gravity model

7.1 Focus on Irish transport costs and modal shares

In Sections 5 and 6 we predicted both the freight costs and modal shares for each $ijkt$ flow. For the final step we simply associate these predicted values and the BACI database flows (64 main trading countries, HS6 level, 2012-2015). This new database contains, for each product, the value traded but also numerous trade costs, including freight costs, and the modal shares.

We performed the predictions for all flows from BACI, but we are specifically interested in the Irish trade. Concerning the transport modes, we know that all products leaving Ireland by road are either directly destined for Northern Ireland or are exported by ship from there. Because of the lack of detailed data regarding the land-bridge use, we cannot directly obtain the share of Irish trade using the land-bridge. We predicted this share for Irish trade using the estimates derived from all data. We consider, as a proxy, that the products leaving Ireland by road (and whose final destination is not Northern Ireland) correspond to the use of the land-bridge.

We are interested in the trade between Ireland and France, which is dominated by meat and dairy products. Table 8 presents the most exported (in value) products from Ireland to France in 2015, and the predicted associated AVTC and modal shares.[20] We assume the most traded products will be particularly vulnerable to Brexit. We observe a high proportion of road share for the main exported products, in spite of the fact that the AVTC road is always higher than the sea one. As an example, the AVTC road for Ireland as exporter goes from 21.4 (destination UK) to 70.0 (destination Singapore) for the HS6 product 020130 (chapter: meat of bovine animals), which is one of the most exported Irish products.

Most of the main exported products (all modes confounded) belong to higly perishable categories: meat, dairy, fish and preparations of cereals. Table 9 presents the exported products from Ireland to France using the most the sea route in 2015, and the predicted associated AVTC and modal shares. These products belong to low perishable categories, such as milling products or beverages. Table 10 is similar to Table 9 but for the road route. In line with our assumptions, hishly perishable products use mainly the road, such as live animals or fish. We already discussed the live trees and vegetable plaiting materials in Section 6.3. In the following we use the constructed database and a standard gravity model to assess Brexit potential impacts on Ireland exports through the land-bridge additional costs.

20. See https://www.foreign-trade.com for the HS6 corresponding products.

Table 8: Most exported products: value, AVTC and shares, the case of Ireland to France

HS6	Chapter	Value (M€)	AVTC sea	AVTC road	Sea share	Road share
020130	2 Meat and edible meat offal	116.8	2.80	26.29	6.2%	93.8%
020230	2 Meat and edible meat offal	75.2	2.82	26.56	6.3%	93.7%
040500	4 Dairy produce	62.8	2.83	26.75	11.2%	88.8%
020410	2 Meat and edible meat offal	40.9	2.80	26.24	6.2%	93.8%
040690	4 Dairy produce	39.8	2.81	26.43	11.0%	89.0%
210120	21 Miscellaneous edible prep.	36.5	2.71	24.78	6.0%	94.0%
030212	3 Fish and crustaceans	31.7	2.79	26.09	4.6%	95.4%
190110	19 Preparations of cereals	27.0	2.82	26.60	7.5%	92.5%
220210	22 Beverages, spirits and vinegar	26.5	2.83	26.87	12.5%	87.5%
040229	4 Dairy produce	25.4	2.83	26.78	11.2%	88.8%
020120	2 Meat and edible meat offal	22.3	2.79	26.09	6.1%	93.9%
020610	2 Meat and edible meat offal	22.0	2.81	26.47	6.3%	93.7%
220830	22 Beverages, spirits and vinegar	21.7	2.81	26.55	12.4%	8.76%
030710	3 Fish and crustaceans	21.6	2.81	26.38	4.7%	95.3%
170490	17 Sugars and sugar confectionery	20.5	2.78	25.95	8.6%	91.4%
020422	2 Meat and edible meat offal	17.7	2.79	26.20	6.2%	93.8%
020421	2 Meat and edible meat offal	17.4	2.80	26.27	6.2%	93.8%
020423	2 Meat and edible meat offal	15.5	2.79	26.18	6.2%	93.8%
030624	3 Fish and crustaceans	14.3	2.80	26.38	4.7%	95.3%
220300	22 Beverages, spirits and vinegar	13.6	2.86	27.30	12.8%	87.2%

Note: AVTC: Ad-valorem trade cost

Table 9: Most sea exported products: value, AVTC and shares, the case of Ireland to France

HS6	Chapter	Value (M€)	Sea share	AVTC sea	AVTC road
110100	11 Products of the milling industry	1.06	15.6%	2.92	28.47
110220	11 Products of the milling industry	0.02	15.2%	2.89	27.89
110290	11 Products of the milling industry	0.00	15.0%	2.88	27.62
110422	11 Products of the milling industry	0.00	14.6%	2.84	27.05
110610	11 Products of the milling industry	0.01	14.4%	2.82	26.60
110630	11 Products of the milling industry	0,00	14,3%	2,82	26,55
230990	23 Residues and waste from the food industries	2.57	14.1%	2.90	28.03
230230	23 Residues and waste from the food industries	0.02	14.1%	2.90	28.03
110412	11 Products of the milling industry	0.00	14.0%	2.79	26.09
230120	23 Residues and waste from the food industries	0.54	13.8%	2.87	27.50
230910	23 Residues and waste from the food industries	0.09	13.8%	2.87	27.46
220110	22 Beverages, spirits and vinegar	0.06	13.2%	2.90	27.99
220421	22 Beverages, spirits and vinegar	0.04	12.9%	2.87	27.59
220290	22 Beverages, spirits and vinegar	0.00	12.9%	2.87	27.45
220300	22 Beverages, spirits and vinegar	13.56	12.8%	2.86	27.30
220600	22 Beverages, spirits and vinegar	1.40	12.7%	2.85	27.20
220210	22 Beverages, spirits and vinegar	26.48	12.5%	2.83	26.87
220830	22 Beverages, spirits and vinegar	21.74	12.4%	2.81	26.55
220850	22 Beverages, spirits and vinegar	0.01	12.1%	2.79	26.12
220890	22 Beverages, spirits and vinegar	11.71	12.1%	2.78	25.97

Note: AVTC: Ad-valorem trade cost

Table 10: Most road exported products: value, AVTC and shares, the case of Ireland to France

HS6	Chapter	Value (M€)	Road	AVTC sea	AVTC road
060299	6 Live trees and other plants	0.38	100%	2.84	26.99
060491	6 Live trees and other plants	0.14	100%	2.86	27.29
140490	14 Vegetable plaiting materials	0.46	99%	2.89	27.83
010111	1 Live animals	12.71	98%	2.64	23.68
010119	1 Live animals	0.17	98%	2.73	25.17
010410	1 Live animals	0.84	98%	2.81	26.48
010120	1 Live animals	0.03	98%	2.82	26.59
010290	1 Live animals	1.13	98%	2.82	26.72
010210	1 Live animals	0.31	98%	2.83	26.76
160530	16 Preparations of meat, of fish or of crustaceans	2.03	97%	2.76	25.66
160540	16 Preparations of meat, of fish or of crustaceans	0.03	96%	2.78	25.91
160520	16 Preparations of meat, of fish or of crustaceans	0.62	96%	2.78	25.93
160420	16 Preparations of meat, of fish or of crustaceans	0.28	96%	2.78	26.01
160231	16 Preparations of meat, of fish or of crustaceans	1.28	96%	2.79	26.14
160241	16 Preparations of meat, of fish or of crustaceans	1.80	96%	2.79	26.17
160249	16 Preparations of meat, of fish or of crustaceans	0.42	96%	2.80	26.26
160239	16 Preparations of meat, of fish or of crustaceans	2.84	96%	2.81	26.39
160419	16 Preparations of meat, of fish or of crustaceans	0.20	96%	2.81	26.41
160242	16 Preparations of meat, of fish or of crustaceans	0.39	96%	2.81	26.50
160290	16 Preparations of meat, of fish or of crustaceans	0.29	96%	2.81	26.52

Note: AVTC: Ad-valorem trade cost

7.2 Assessing Brexit impacts through the UK land-bridge cost with a gravity model

What could be the Brexit impacts on Irish agri-food exports? We believe the cost linked to the land-bridge has been underestimated or left behind, in the Brexit literature. To take these costs into account, we propose an approach, with possible variations, using our tailored database in a gravity model. This is an illustration among others, as the base could be used for other purposes. The strong point on this approach is that, in addition to the trade costs traditionnally used in gravity models (tariffs, NTMs, regional trade agreement dummy, colony, etc) we augmented our database with freight rates and modal shares.

We assume that Brexit will lead to a change in road freight cost or the time cost between Ireland and France, corresponding to the additional administrative procedures cost related to the land-bridge use. They are post-Brexit new costs. We present a standard gravity model, allowing to assess the impact of a change in modal shares on the total bilateral trade. The traditional gravity model is the workhorse for studies on the pattern of trade and influence of transport costs (Brun et al., 2005).

In our example, in addition to the tariffs and NTMs, one would play with the freights costs ratios and distances ratios. Post-Brexit new modal shares can be computed through the marginal effects of AVTC and time cost, previously predicted. The new modal shares result from the modal report, from the road to the maritime mode. In the modal shares are included the effects of the difference in time costs and direct freight costs between the modes (distances ratios and AVTC ration). The hypothesis here is that the modal shares include all the transport variables (*i.e.* the difference in costs between the two modes). We also add to the explanatory variables the log of the weighted distance as a proxy for absolute transport cost. [21] Through the modal shares changes the corresponding change in the total Irish exported value can be predicted with a traditionnal gravity model. We run a simple gravity model using the OLS estimator. We estimate coefficients of the equation (5):

$$\begin{aligned} \ln(V_{ijkt}) &= \beta_0 + \beta_1 \ln(sea\ share_{ijkt}) + \beta_2 \ln(distw_{ij}) + \beta_3\, EIA_{ijkt} + \beta 4\, lang_{ij} \\ &\quad + \beta_5\, colony_{ij} + \phi_{it} + \chi_{jt} + \psi_{HS4} + \epsilon_{ijkt} \end{aligned} \tag{5}$$

With V_{ijkt} the value traded for each exporter i to importer j for the product k the year t, $\ln(sea\ share_{ijkt})$ the log of the sea share, for each $ijkt$, $\ln(distw_{ij})$ the weighted distance between i and j, EIA_{ijkt} the level of participation to a common Economic Integration Agreement (EIA), from 0 to 6, $contiguity_{ij}$ $lang_{ij}$ and $colony_{ij}$ are dummy variables equal to one when countries share a common land border, language, or colonial past. We use

21. Weighted distance corresponds to the distance between two countries based on bilateral distances between the biggest cities of those two countries, those inter-city distances being weighted by the share of the city in the overall country's population. Source: http://www.cepii.fr/distance/noticedist_en.pdf

the regulatory NTM distance $distNTM$ as a novel strategy to proxy the discrepancies in NTMs across countries (Cadot et al., 2018 method, replicated in Cheptea et al., 2020 and Chapter II of the present thesis). ϕ_{it} is an exporter-time fixed-effect , χ_{jt} an importer-time fixed-effect, ψ_{HS4} a chapter fixed-effect, and ϵ_{ijkt} is a zero-mean error term.

Table 11 presents the estimation results for the aggregated agri-food sector (estimation by chapter could also be run). In the four columns, the specifications are the same, we just add or remove some of the explanatory variables, for the robustness. We do find the traditional effects of gravity equations, *i.e.* a positive effect on trade flows if the two countries have a common border, or a common language, or a common colonial past. Tariffs have a negative impact on trade flows, and the NTM distance is not significant. We observe that a larger sea share implies a decrease in the trade flows, which is probably due to the higher travel time associated to the sea mode. An increase of 10% of the sea share generates a decrease in the traded value of 0.32 to 0.62% (depending on the explanatory variables taken into account).

Table 11: Standard gravity on bimodal trade flows: log. of exported value, OLS

	(1)	(2)	(3)	(4)
ln(sea share)	-0.036***	-0.036***	-0.032***	-0.062***
	(0.003)	(0.003)	(0.003)	(0.003)
ln(distw)	-0.385***	-0.367***	-0.406***	
	(0.009)	(0.007)	(0.006)	
EIA	-0.017***			0.096***
	(0.005)			(0.004)
Contiguity	0.400***	0.400***	0.382***	0.641***
	(0.021)	(0.021)	(0.018)	(0.020)
Common Language	0.077***	0.080***	0.055***	0.163***
	(0.013)	(0.013)	(0.012)	(0.013)
Common Colony	0.083*	0.091*	0.100**	0.063
	(0.039)	(0.039)	(0.036)	(0.039)
ln(1+tariff/100)	-0.150***	-0.149***	-0.139***	-0.151***
	(0.004)	(0.004)	(0.003)	(0.004)
dist NTM	0.185	0.171		0.067
	(0.140)	(0.140)		(0.140)
FE exp-time and chap	Yes	Yes	Yes	Yes
FE imp-time and chap	Yes	Yes	Yes	Yes
R-squared	0.181	0.181	0.175	0.177
Observations	427,979	427,979	527,852	427,979

Significance levels: ***0.01 **0.05 *0.10

8 Discussion and conclusion

8.1 Brexit impacts on Irish trade with gravity

Assuming that freights costs (direct and time) determine new modal shares, we use the sea share as explanatory variable, among others, in a standard gravity model with the trade value (all modes confounded) as dependant variable, with exporter-time, importer-time- and chapter (HS4) fixed effects. We find effects of traditionnal gravity variables consistent with the literature. In addition, as expected, a larger sea share has a negative effect on the total trade flows. An increase of 10% of the sea share generates a decrease in the traded value of 0.32 to 0.62%. This is an additional effect of Brexit that is usually omitted in teh Brexit literature, leading to underestimations of the Brexit impacts on Ireland.

Further work consists in performing a real-world simulation with our model, *i.e.* find out what percentage the land-bridge travel time roughly increase through Brexit, adapt it to our distance and sqaured distance ratios, and predict new sea shares. Once we obtain new sea shares under different detailed scenarios, depending on the outcomes of the negociations, we can also assume corresponding tariffs, NTM distance or other explanatory variables under the different scenarios. We then could use our gravity model to predict the change in bilateral trade flows, *i.e.* Irish exports to France, but also other EU countries.

With the constructed database, another possibility to assess the land-bridge cost on trade is the use of *ad-hoc* estimated numbers from literature. We illustrate with some examples below. As an illustration, Hummels (2001a) uses the price elasticity of demand and the benefit of time saving: the AVE for time saving is calculated by combining the estimated price elasticity with the benefit measured in day (conversion of time into ad-valorem equivalent, or the value of time relative to the cost of the good). We know that, in the Irish case, the sea route is around one day longer, equivalent to 16% of AVE tariff (Hummels, 2001a). As a consequence, the mode switch would be equivalent to a 16% of AVE tariff. Using a gravity model with freight costs and tariffs (and potentially other trade costs such as NTMs) we could then take into account the maritime delay impact compared to the road mode. As a second illustration, according to Korinek and Sourdin (2009), time spent in transit has a strong effect on trade: an extra day spent at sea on an the average sea voyage of 20 days implies a 4.5% drop in trade between a given pair of trading partners.

8.2 Limitations and potential improvements of the tailored database

Even if freight costs have been widely studied in the literature, EU freight data remain scare and most of the time incomplete. We intented to circumvent the issue of lack of data by creating them, based on a variation of the Hummels et al. (2014) approach. We build a tailored database in order to obtain detailed transport data, aiming to address the

land-bridge question in Irish trade. To validate the robustness of the method, a comparison with direct Irish data would be valuable, but unfortunately they do not exist or are not available.

We are aware that more details concerning each mode are important and should be taken into account in our estimations and predictions. However, at a disaggregated level, such data do not exist, or they can hardly be considered. For instance, some fixed costs depending on the countries considered,[22] or RoRo and LoLo operating systems, are important charasteristics. These two latter methods entail different costs (in time and money). In addition, maritime transport costs depend on the segment of the shipping market that is delivering the goods: agricultural products are shipped in different ways – in containers for some products, or by bulk transporters for grains and some oilseeds. Transportation costs in these two maritime transport sub-markets are only imperfectly correlated and often account for very different shares of the final import cost of goods. Generally, goods shipped in containers are found to have lower transport costs per tonne of merchandise shipped, as are those on well-travelled trade routes between major ports (Korinek and Sourdin, 2009). These subtleties are out of scope in this paper.

Otherwise, one of the strong hypotheses is that the exporting freight costs have the same structure if importers are non-EU or EU, since the estimation is performed on non-EU importers. This could lead to overestimated costs, since the low GDP country usually have lower quality infrastructures. In addition, through the literature we highlighted the importance to include the timeliness (or delay, or time cost), beyond the pure direct freight costs. Some papers deliver such an information but not detailed enough for our goal, as we need time information in function of the trade partners and the mode used, at a disaggregated level. We included the relative time costs through the distances and squared distances ratios. Another option to take into account the time costs is to proxy them with specific kinds of NTM. For instance, Byrne et al. (2018) estimate the potential post-Brexit loss in trade between Ireland and the UK arising from increases in NTMs as delay proxy.

In our constructed database, we observe that freight costs range doesn't vary a lot for a given country pair and mode. We then assume that the product dependant variable, namely UV, does not count a lot in the AVTC value. However, variations from a mode to another, or for a country pair to another are more important, especially in the case of road freight cost, generally with lower cost for the UK as destination, for Irish exports.

22. According to the literature, freight costs can depend on the countries wealth, through *e.g.* the infrastructure quality of exporter and importer.

8.3 Extension: transport modes and environmental impacts

Future development of sea transportation

Over the last 50 years, seaborne trade has seen a remarkable development. Shipping carries the vast majority of international trade with its share ranging between 80 and 90% of trade. In terms of trade value, of course, the shipping share is considerably lower with various estimates hovering around 60 to 70% of trade. [23] In the Brexit context, the maritime route development could keep developing. Not only a modal report (from road to sea) could occur, but *"maritime highways"* are downright in the process pipes, between Ireland and countries such as Spain. The sea travel would take 26 hours but will shave around 1 200km off the road journey for many hauliers currently opting for a land-bridge via Rosslare, the UK and France down to Spain. The route could be used for both tourists travel (example with the Brittany Ferries) but also for commodity trade, especially for Irish fish and seafood exporters sending huge volumes of produce to France and Spain while there is also a substantial trade in the other direction in everything from fruit and vegetables to wines as well as ceramics and timber. [24]

Pollution and transport modes

The transport modes can bring another question, not addressed in this paper, namely the associated pollutions. It is clear that the different modes have different consequences on environmental indices such as the level of biodiversity, water pollution or climate change. On the one hand, the land-bridge use by Irish trucks seems to boost air pollution in the UK. [25] Indeed, this is a typical example of externality: Irish exporters are using the UK road but the associated pollution (carbon dioxide released by trucks) impacts the British people. Considering this aspect, a modal report to the sea may improve the air quality in the UK. On the other hand, if generally most of the studies are focused on air pollution and climate change, other kinds of pollution are usually left behind. Like all modes of transportation that use fossil fuels, ships produce carbon dioxide emissions that significantly contribute to global climate change and acidification. But besides carbon dioxide, ships also release a handful of other pollutants, *e.g.* release of oil and chemicals, transfer of invasive alien species, or dumping of waste. [26]

Over 90% of world trade is carried across the world's oceans by some 90 000 marine vessels, and we believe a modal report will occur in favor of the sea following Brexit, still increasing this number. Using the pollutions types, or a global pollution index associated to each mode, we propose a possible extension of this paper. It would consist in using the modal shares variation to assess the environmental impacts of Brexit, or another kind of policy change.

23. https://unctad.org
24. https://www.irishtimes.com
25. https://theconversation.com
26. https://eu.oceana.org

8.4 Conclusion

We built a tailored database at a disaggregated level (HS6) including transport modes, transport costs and modal shares for each flow, in order to provide a detailed information for assessing the Brexit impacts in connection with the potential additional land-bridge costs. Transport costs are most of the time omitted from the Brexit studies, or proxied by the bilateral distance, leading to an underestimation of the Brexit impact for Irish trade. We focused on the agricultural and agri-food sector (HS chapters from 1 to 24), particularly sensitive to time cost, belonging to transport costs. Among transport costs we computed the AVTC and proxies for the time cost relative to each mode. AVTC does not vary a lot into a mode and a given country pair, but higher variations are observed from a country pair to another. Road AVTC are much higher than sea AVTC. We use a MFL model to assess the impacts of AVTC and time costs on modal shares (*i.e.* modal report). These impacts vary a lot infunction of the chapter. We assume the products perishability is one of the determinants. We use the sea share variable in a standard gravity model to quantify the impact of the modal share variation in the total exports from Ireland to France. We found, as expected, that a higher sea share generated a decrase in the bilateral trade.

Appendix A – Data details

A1 Databases references

- **ITGS (2019)**. International Trade in Goods Statistics - Comext. Eurostat, Brussels, Belgium. Retrieved on May 1, 2019 from http://epp.eurostat.ec.europa.eu/newxtweb/, International Trade / EXTRA EU Trade Since 2000 By Mode of Transport (HS6) (DS-043328)

- **BACI (2019)**. International Trade Database at the Product-Level - Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). The 1994-2007 Version. Retrieved on July 2019 from http://www.cepii.fr - Technical report: Gaulier and Zignago (2010).

- **Gravdata (2019)**. Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). The 1948 and 2015 version. Retrieved on January 1, 2018 from http://www.cepii.fr.

- **Fuel price (2019)**. International Monetary Fund (IMF). Retrieved on July 2019 from https://www.imf.org

- **ITIC (2019)**. The International Transport and Insurance Costs - OECD. Retrieved on May 1, 2019 from https://stats.oecd.org. Miao and Fortanier (2017).

- **Bertoli, S., Goujon, M., and Santoni, O. (2017)**. The CERDI-seadistance database, version 1.1. Retrieved on April 10, 2019 from http://doi.org/10.5281/zenodo.240493.

- **TRAINS (2018)**. Trade Analysis Information System (2018) - UNCTAD. [27] Retrieved on January 2018 from https://unctad.org.

A2 Subset of exporters (EU) and importers (non-EU) from Comext ITIC database selected for the estimations

Exporters: Belgium-Luxembourg, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden.

Importers: Afghanistan, Albania, Algeria, Andorra, Angola, Armenia, Azerbaijan, Bahrain, Bangladesh, Belarus, Benin, Bhutan, Bolivia Plurinational State of, Bosnia Herzegovina, Brunei Darussalam, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Rep., Chad, China, China Hong Kong SAR, China Macao SAR, Comoros, Congo, Côte dIvoire, Dem. Peoples Rep. of Korea, Dem. Rep. of the Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, FS Micronesia, Gabon, Gambia, Georgia, Ghana, Gibraltar, Guinea, Guinea-Bissau, India, Indonesia, Iran, Iraq, Israel, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Lao Peoples Dem. Rep., Lebanon, Liberia, Libya, Madagascar, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius,

27. United Nations Conference on Trade and Development

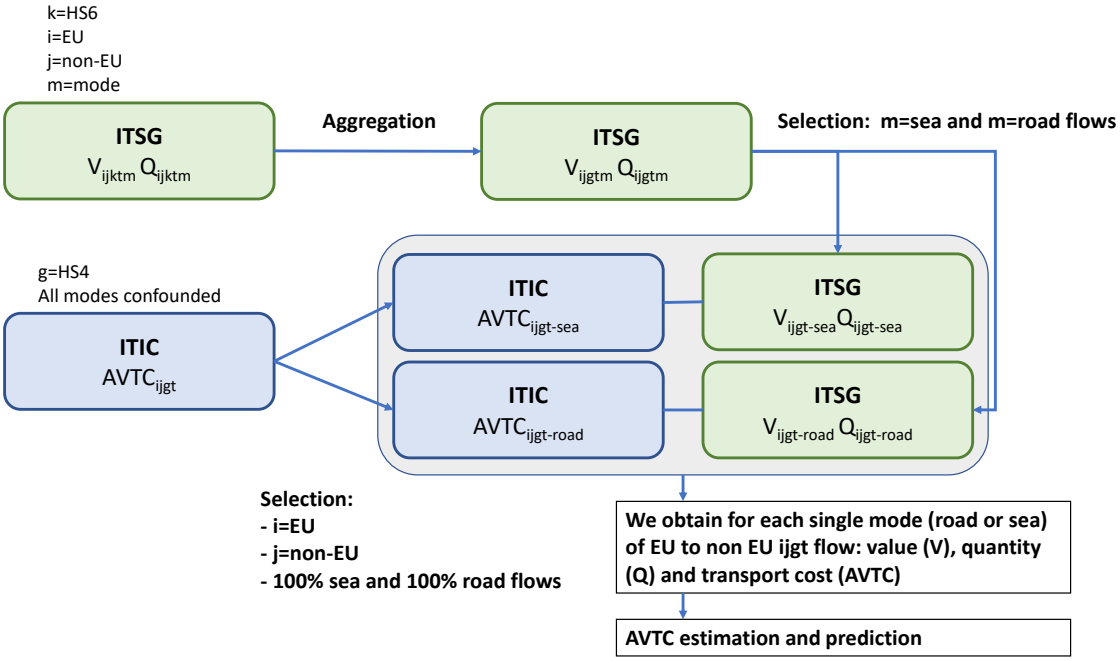
Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Nepal, Niger, Nigeria, Norway, Oman, Other Asia nes, Pakistan, Peru, Qatar, Rep. of Korea, Rep. of Moldova, Russian Federation, Rwanda, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, So. African Customs Union, Somalia, Sri Lanka, State of Palestine, Sudan, Switzerland, Syria, TFYR of Macedonia, Tajikistan, Thailand, Togo, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Rep. of Tanzania, Uzbekistan, Viet Nam, Yemen, Zambia, Zimbabwe.

Table A1: HS Chapters

Number	Name
01	Live animals
02	Meat and edible meat offal
03	Fish and crustaceans, molluscs and other aquatic invertebrates
04	Dairy produce; birds eggs; natural honey; edible products of animal origin, not elsewhere specified or included
05	Products of animal origin, not elsewhere specified or included
06	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage
07	Edible vegetables and certain roots and tubers
08	Edible fruit and nuts; peel of citrus fruit or melons
09	Coffee, tea, maté and spices
10	Cereals
11	Products of the milling industry; malt; starches; inulin; wheat gluten
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruits; industrial or medicinal plants; straw and fodder
13	Lac; gums, resins and other vegetable saps and extracts
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included
15	Animal or vegetable fats and oils and their cleavage products prepared edible fats; animal or vegetable waxes
16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates
17	Sugars and sugar confectionery
18	Cocoa and cocoa preparations
19	Preparations of cereals, flour, starch or milk; bakers' wares
20	Preparations of vegetables, fruit, nuts or other parts of plants
21	Miscellaneous edible preparations
22	Beverages, spirits and vinegar
23	Residues and waste from the food industries; prepared animal feed
24	Tobacco and manufactured tobacco substitutes

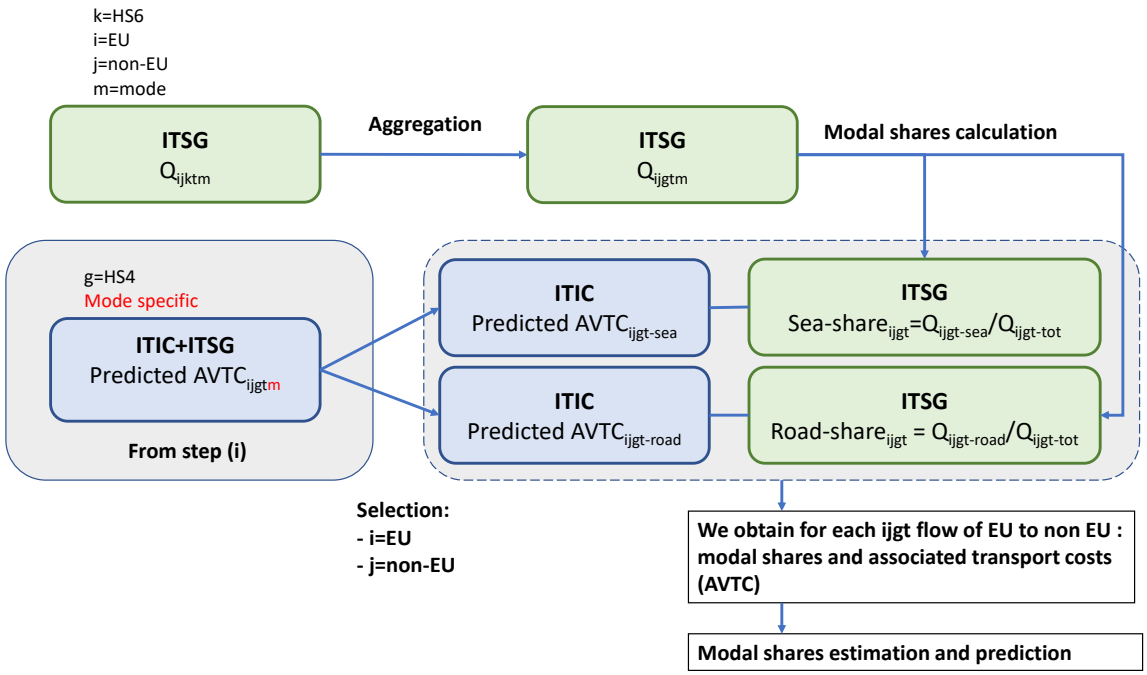
Appendix B – Modelling summary

Figure B1: Summary of the ITIC and ITGS databases harmonization for the step (i)



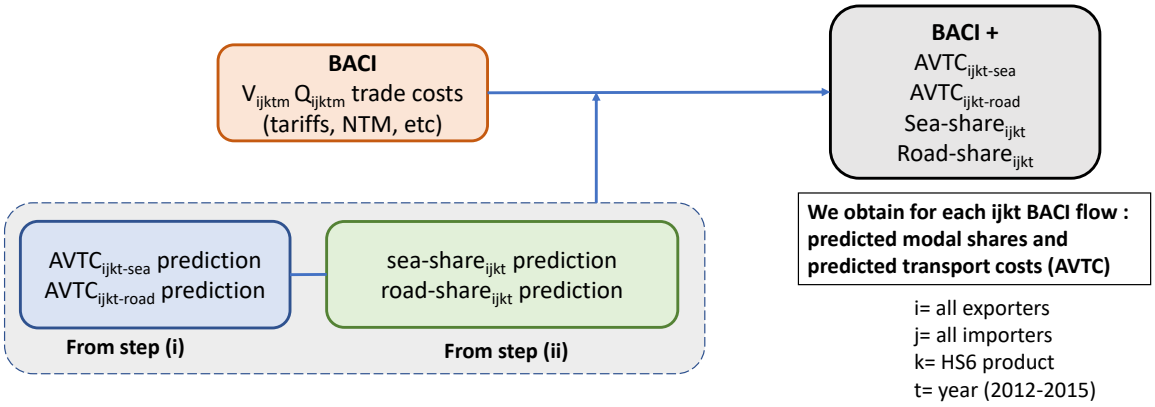
Source: Authors of the present study

Figure B2: Summary of the ITIC and ITGS databases uses for the step (ii)



Source: Authors of the present study

Figure B3: Summary of the BACI, ITIC and ITGS databases uses for the step (iii)



Source: Authors of the present study

Appendix C – Multinomial fractional logit by HS chapter

Table C1: Multinomial fractional logit, sea shares by chapter, chapters 1 to 8

Chapters	1	2	3	4	5	6	7	8
AVTC road/AVTC mar	0.092**	0.396***	0.368***	0.352***	0.324***	0.185***	0.310***	0.284***
	(0.034)	(0.014)	(0.015)	(0.012)	(0.023)	(0.025)	(0.010)	(0.010)
dist sea/dist road	-0.331	-0.617***	-0.950***	-0.022	-0.471***	0.018	-0.605***	-0.395**
	(0.406)	(0.071)	(0.077)	(0.155)	(0.116)	(0.509)	(0.088)	(0.139)
(dist sea/dist road)^2	-0.097	0.048***	0.064***	-0.043	0.028*	-0.207	0.027	-0.017
	(0.084)	(0.008)	(0.010)	(0.029)	(0.013)	(0.120)	(0.015)	(0.028)
Contiguity	-16.202***	-2.078***	-2.181***	-2.709***	-1.694***	-3.833***	-1.607***	-2.511***
	(0.245)	(0.285)	(0.408)	(0.421)	(0.452)	(0.868)	(0.238)	(0.357)
Colony	-14.026***	-3.685**	-2.389***	-2.424***	-20.856***	-14.822***	-16.762***	-7.044***
	(0.431)	(1.166)	(0.560)	(0.448)	(0.831)	(0.260)	(0.184)	(1.010)
Common Language	0.472	0.839***	0.441*	1.745***	0.370	1.270***	0.486***	1.530***
	(0.305)	(0.180)	(0.205)	(0.186)	(0.239)	(0.335)	(0.119)	(0.155)
Constant	-1.133*	-4.588***	-3.426***	-4.374***	-3.571***	-2.711***	-3.596***	-3.432***
	(0.494)	(0.254)	(0.262)	(0.207)	(0.380)	(0.422)	(0.182)	(0.164)
Observations	681.000	4499.000	2992.000	7505.000	1251.000	947.000	5758.000	5869.000

Significance levels: ***0.01 **0.05 *0.10

Table C2: Multinomial fractional logit, sea shares by chapter, chapters 9 to 16

Chapters	9	10	11	12	13	14	15	16
AVTC road/AVTC mar	0.368***	0.356***	0.334***	0.308***	0.284***	0.272***	0.277***	0.410***
	(0.014)	(0.022)	(0.012)	(0.014)	(0.027)	(0.041)	(0.011)	(0.021)
dist sea/dist road	-0.572***	-0.920***	-0.354***	-0.699***	-0.594	0.074	-0.728***	-0.366
	(0.067)	(0.123)	(0.077)	(0.140)	(0.475)	(0.557)	(0.200)	(0.290)
(dist sea/dist road)^2	0.052***	0.064***	0.015	0.014	-0.014	-0.212	0.022	-0.010
	(0.006)	(0.017)	(0.010)	(0.027)	(0.107)	(0.123)	(0.041)	(0.057)
Contiguity	-1.707***	-1.515***	-2.274***	-2.726***	-0.963	-3.406***	-3.113***	-0.938*
	(0.224)	(0.396)	(0.300)	(0.392)	(0.689)	(0.677)	(0.332)	(0.462)
Colony	-17.533***	-14.850***	-17.460***	-14.357***	-15.030***	-21.228***	-15.860***	-1.746**
	(0.455)	(0.567)	(0.260)	(0.356)	(0.510)	(1.017)	(0.320)	(0.658)
Common Language	1.536***	0.557**	1.219***	0.954***	1.223***	0.695	0.712***	1.256***
	(0.142)	(0.211)	(0.137)	(0.173)	(0.267)	(0.483)	(0.110)	(0.231)
Constant	-4.545***	-3.159***	-3.625***	-3.014***	-2.630***	-2.805***	-2.283***	-5.224***
	(0.249)	(0.332)	(0.202)	(0.210)	(0.397)	(0.528)	(0.179)	(0.312)
Observations	3350.000	1697.000	5384.000	3592.000	1136.000	463.000	8245.000	3393.000

Significance levels: ***0.01 **0.05 *0.10

Table C3: Multinomial fractional logit, sea shares by chapter, chapters 17 to 24

Chapters	17	18	19	20	21	22	23	24
AVTC road/AVTC mar	0.320***	0.309***	0.342***	0.282***	0.332***	0.313***	0.297***	0.259***
	(0.015)	(0.015)	(0.012)	(0.008)	(0.010)	(0.008)	(0.015)	(0.023)
dist sea/dist road	-0.614***	-0.358*	-0.353**	-0.577***	-0.581***	-0.233**	-0.525***	-0.619***
	(0.116)	(0.177)	(0.133)	(0.080)	(0.069)	(0.087)	(0.113)	(0.135)
(dist sea/dist road)²	0.040*	-0.026	-0.011	0.020	0.036***	-0.019	0.015	0.018
	(0.017)	(0.036)	(0.025)	(0.014)	(0.010)	(0.015)	(0.018)	(0.023)
Contiguity	-2.943***	-2.804***	-3.024***	-1.625***	-2.190***	-1.293***	-1.074***	-2.000***
	(0.444)	(0.639)	(0.361)	(0.234)	(0.238)	(0.221)	(0.251)	(0.387)
Colony	-3.090***	-15.200***	-16.838***	-3.760***	-3.867***	-3.012***	-14.647***	-10.062***
	(0.779)	(0.240)	(0.206)	(0.783)	(1.037)	(0.469)	(0.423)	(1.089)
Common Language	1.584***	1.131***	1.262***	0.932***	1.098***	1.249***	0.525**	0.484
	(0.174)	(0.227)	(0.173)	(0.102)	(0.130)	(0.121)	(0.163)	(0.260)
Constant	-3.368***	-3.352***	-3.865***	-2.704***	-3.851***	-3.423***	-2.558***	-1.899***
	(0.256)	(0.256)	(0.201)	(0.139)	(0.183)	(0.153)	(0.239)	(0.347)
Observations	3285.000	3108.000	6442.000	9788.000	6274.000	10674.000	3313.000	1567.000

Significance levels: ***0.01 **0.05 *0.10

Table C4: Multinomial fractional logit, marginal effect on the sea shares by chapter, chapters 1 to 8

Chapters	1	2	3	4	5	6	7	8
AVTC road/AVTC mar	0,0119	0,0410	0,0405	0,0384	0,0371	0,0259	0,0434	0,0412
dist sea/dist road	-0,0428	-0,0639	-0,1047	-0,0025	-0,0540	0,0025	-0,0848	-0,0573
(dist sea/dist road)²	-0,0125	0,0049	0,0071	-0,0046	0,0032	-0,0290	0,0038	-0,0025

Table C5: Multinomial fractional logit, marginal effect on the sea shares by chapter, chapters 9 to 16

Chapters	9	10	11	12	13	14	15	16
AVTC road/AVTC mar	0,0459	0,0420	0,0352	0,0390	0,0381	0,0326	0,0334	0,0449
dist sea/dist road	-0,0713	-0,1088	-0,0373	-0,0885	-0,0798	0,0089	-0,0880	-0,0401
(dist sea/dist road)²	0,0065	0,0076	0,0016	0,0018	-0,0019	-0,0254	0,0027	-0,0010

Table C6: Multinomial fractional logit, marginal effect on the sea shares by chapter, chapters 17 to 24

Chapters	17	18	19	20	21	22	23	24
AVTC road/AVTC mar	0,0417	0,0404	0,0400	0,0360	0,0441	0,0341	0,0345	0,0352
dist sea/dist road	-0,0800	-0,0468	-0,0413	-0,0737	-0,0772	-0,0254	-0,0609	-0,0840
(dist sea/dist road)²	0,0052	-0,0034	-0,0013	0,0025	0,0048	-0,0020	0,0017	0,0024

General Conclusion

1 Main contributions and results

Since the June 23, 2016 referendum surprise, many political twists, negotiations, debates, resignations and announcements happened. Finally, since January 31, 2020, the United-Kingdom (UK) is no longer part of the European Union (EU), and from January 1, 2021, it will no longer be binded by its trade agreements, whether or not an agreement is reached on the new relationship between the UK and the EU. This actual exit represents a leap into the unknown. This unprecedented event gave rise to numerous studies aiming to predict the post-Brexit economic consequences, using a wide range of methods, indexes, assumptions, scenarios, data and panels of countries or areas of study. However, few studies exist on the agri-food sector. My doctoral research aimed to lift the veil on certain aspects of Brexit consequences. More precisely, **the general objective of my doctoral research was to evaluate the Brexit impacts on the EU agri-food trade.** To assess these impacts, we chose original combinations of specifications, cases and variables, using data over the four years prior to the Brexit vote (2012 to 2015).

Chapter I

First of all, **Chapter I** reviews the literature on Brexit consequences on agri-food trade. The originality of this paper is to adopt a broad point of view and consider Brexit as a specific illustration of the process of economic and political disintegration, beyond the purely policy change side. We place our review in line with Sampson (2017)'s and Larue (2018)'s work, respectively on Brexit and economic disintegration, but with a focus on agri-food. Considering Brexit as a disintegration episode, the comparison to older disintegration cases observed in the recent history showed that Brexit represents a different kind of disintegration. We question whether Brexit could be the first step towards more disintegration.

On the one hand, if Brexit is the beginning of a new wave of disintegration, we expect that the interest in disintegration will be increasing and methods to assess its consequences will improve in the coming years. Indeed, the integration and disintegration literature review highlighted the fact that disintegration has been mainly studied as the reverse process of integration. This method can bring issues for certain types of trade costs. For instance, there is no consensus concerning the treatment of the reintroduction of non-tariff measures (NTMs) between partners. We believe the integration methods applied to disintegration may not be totally adapted.

On the other hand, we would like to qualify the hypothesis of a new period of EU disintegration. We observed that Brexit may have been caused, at least partially, by a tension between the sovereignty and the EU supra-national power induced by a deep economic integration, questionning the optimal level of governance. To further discuss these questions, we propose to add an original element in the last section of the present conclusion, namely the new global health and environmental crises. While the recent COVID-19 pandemic and

the increased frequency and severity of extreme weather phenomena induced by climate change threaten the integrity and population's access to these common goods, a right level of governance could ease or temper these issues, and even promote a EU supra-national power.

Following the warnings from Hornok and Koren (2017) when they summarize the state of the art in research in international trade and global production, we pinpoint that given the scope of the task, our survey is admittedly very selective. We have chosen topics that we think are important for both European policy and academic research. Even among the topics we cover, our discussion can only scratch the surface of the academic debate. We did not intend to give a comprehensive survey in all the topics. Instead, we just summarized the consensus if there is one, and judiciously discussed the open questions. When necessary, we tried to highlight the key papers, but often just referred to the conclusions of these surveys.

Chapters II and III

In international trade economics, the standard gravity model is one of the most popular and successful frameworks for assessing or predicting trade policy changes impacts. Hundreds of papers have used the gravity equation to study and quantify the effects of various determinants of international trade. Standard gravity models definitely are a workhorse model of international trade economics. But gravity models have undergone a lot of evolution and improvements in recent years. The structural version of the gravity model has developped drastically, with the theoretical micro foundations and the use of multilateral resistance (MR) terms. The last few years, the use of the structural gravity has been growing, for instance in the Brexit literature.

Considering Brexit as a policy change in **Chapters II and III**, we have adopted an approach based on the structural gravity model with MR terms and the Pseudo Poisson Maximum Likelihood (PPML) estimator, in order to obtain the full endowment general equilibrium effects, in addition to the direct effects (Yotov et al., 2016). Indeed, the general equilibrium framework of the structural gravity model permits to account for direct effects (changes in trade costs of concerned flows), as well as for indirect effects (changes in trade costs between other partners and worldwide adjustments in terms of price indices, supply and demand) on global trade patterns. Our data panel is composed of the world's largest 57 exporters and importers of agri-food products and covers 75% of global trade in these goods. Dhingra et al. (2017) and Oberhofer and Pfaffermayr (2018) belong to the same trend of literature than our work. They also choose a structural gravity framework for assessing Brexit impacts, but our analyses differ from this branch of literature on several points, evoked below together with the usual limitations and novelty we proposed:

- Concerning the methodological differences, Dhingra et al. (2017) use a Costinot and Rodríguez-Clare (2014) version of structural gravity (which is an extension of the Eaton and Kortum (2002) model), while Oberhofer and Pfaffermayr (2018) use an Anderson

et al. (2018) version of structural gravity, including full endowment general equilibrium effects, just like us.

- We consider only the agri-food sector (harmonized system –or HS– chapters 1 to 24), independently from the other sectors, such as manufacturing, services, *etc*, while they consider the whole economy, divided in sectors. On the one hand, the limit associated with the agri-food focus is the lack of interactions between sectors. On the other hand, as we used a very disaggregated level of data (HS6-level), the aggregation into products categories (or even in a unique agri-food sector) for the estimations and simulations was very flexible and allowed a more detailed analysis, by product category. In addition, our model could be applied to any sector.
- Our scenarios consider not only the UK-EU potential trade agreements, but also UK-third countries' ones, and go beyond the two usual extreme scenarios, namely the *status quo* (soft Brexit) and the loss of all current UK's trade agreements with a return to World Trade Organization (WTO) rules (hard Brexit), as we propose in-between scenarios where the UK unilaterally lowers its importation tariffs, or concludes preferential trade agreements (PTAs) only with its favored non-EU countries.
- Concerning the trade costs, in addition to the tariffs changes, we propose an original approach for the inclusion of the NTMs into the scenarios. We computed NTM regulatory distances following the approach introduced by Cadot et al. (2015), by category (*e.g.*: sanitary and phyto sanitary –SPS– measures, technical barrier to trade –TBT–). To our knowledge, the regulatory distance has not been used yet in other studies as a determinant of trade flows. It has been used as an indicator of (dis)similarity of countries' NTMs. Dhingra et al. (2017) use ad-valorem estimates of NTMs.
- Following the Yotov et al. (2016)'s recommendation, namely that gravity estimations should be performed with intra-national and international trade flows data, we computed the unobserved domestic trade flows (intra-national) with a structural gravity equation and using importer and exporter fixed effects estimated with observed international trade data. Thereby, we can run the estimations on the full trade matrix with both domestic and international flows. The limitation is the lack of existing domestic trade data, which impedes a potential comparison of our results for intra-national trade flows to real data.
- One of the main limitation in **Chapters II and III** is related to the elasticity of substitution computed from the parameter associated to the tariff variable. In constant elasticy of substitution (CES) models, the elasticity of substitution (between domestic and foreign goods) is equal to the price elasticity of demand, which is the reaction of relative demand to relative prices. The reaction being governed by the elasticity of substitution, the latter often drives the conclusions of the model. This characteristic makes the elasticity a key parameter in modern trade theory and more broadly in international economics (Bajzik et al., 2020). Yet, no consensus on the magnitude of the elasticity exists. In different contexts, researchers tend to obtain substantially different estimates. Schürenberg-Frosch (2015); Bajzik et al. (2020); Raimondi and Olper (2009); Hertel et al. (2007) discuss the

variability of the estimated elasticities in the literature. They depend on the level of aggregation and the econometric method. For agri-food, they usually vary between 3.13 and 7.84 (Raimondi and Olper, 2009). For all sectors confounded, Hertel et al. (2007) estimate a simple mean value of 7.0. Due to this lack of consensus, with plausible changes in the elasticity, the results, including ours, can change a lot. In our **Chapters II and III**, we estimated the elasticity of substitution. Theoretically, this estimated value should be used to predict the Brexit impact in the general equilibrium structural gravity model. But for some product groups our model doesn't converge to a steady equilibrium when we use the estimated value of this parameter. To overcome this limit, we set the value of the elasticity in our models and check the robustness by varying it. We detail below the strategies used in each chapter. Even if our results remain dependent on the estimated or setted elasticity of substitution, we temper this limitation by discussing the results obtained for different values of the elasticity.

- Finally, one limitation is the restricted comparison of our results, since the branch of literature is quite new.

We present in the following the main results and contributions separately for **Chapters II and III**, as well as specific limitations and solutions.

Chapter II

In our **Chapter II** we use a structural gravity model to predict Brexit impacts on trade under five different trade policy scenarios, for all EU members. Concerning the trade determinants estimation, the effect of traditional gravity variables is in line with the empirical trade literature. In addition, the small positive effect of SPS and TBT suggests that for our panel the informational role of SPS and TBT outweighs their perception as barriers to trade, reflecting a trade-enhancing effect.

Concerning more precisely the choice of elasticity (directly linked to the tariff coefficient), at the aggregated agri-food level, we set the elasticity value at 5, and we obtain very similar results for alternative values. At product category level, we let the elasticity of substitution vary across product groups. For seven groups, we use the estimated value of the elasticity, convergence being reached under all scenarios. For the remaining six groups, we set it equal to the smallest positive integer greater than one for which convergence is reached under all scenarios.

The main results suggest that the five scenarios imply a decline in EU imports and exports, and real income. Ireland is the most severely affected within the EU. Under all scenarios, the UK will bear the most important losses in the agri-food sector. In case of an exit with no deal, the negative effects on the EU's real income, as well as on EU's global agricultural exports and imports, are attenuated if the UK continues to apply the EU preferential trade agreements with third countries. The real income of EU consumers decreases under all

scenarios, although it never exceeds 1%. Similarly, we observe a decrease in the overall exports and imports of EU countries in all five scenarios, the effect being the largest (2.2%-2.3%) for no EU-UK trade deal and trade agreements with third countries (S2). While scenarios with no EU-UK trade deal (S2 and S4) generate a relatively small drop in EU's overall exports and imports (-0.7% to -2.3%), the effect on bilateral EU-UK trade may get quite large: -30% to -37%.

The European *"Meat and meat products"* sector appears to suffer the most from Brexit if no EU-UK trade deal is reached (scenarios S2 and S4). Overall EU exports in this product group would drop by 5.7%-8.5%, while EU exports to the UK would shrink by a third. Ireland is particularly vulnerable in this sector: it registers the strongest decrease in global trade within the EU (comparable to the decrease faced by the UK) and the lowest decrease in exports to the UK. This result is induced by the strong interconnection of Irish producers with British value chains and their increased difficulty to access the EU and extra-EU markets. The absence of a post-Brexit EU-UK trade agreement will also have a strong negative impact on EU exports in product groups *"Fruit"* and *"Vegetables"*.

Chapter III

In **Chapter III** we use the structural gravity at the regional level. In order to perform this assessment using the structural gravity, we split France into two different entities: Brittany and the rest of France. Analyses at the level of sub-national regions remain scarce in the Brexit literature and focus on the effects on the economy as a whole, without differentiation by sector or type of product. For instance, there are two main European regional studies in the literature. Even more striking, to our knowledge, there was no study measuring the impacts on Brittany's agri-food trade, a gap that we fill.

Countries do not collect data on domestic flows, and less so on inter- and intra-regional trade. As a result, domestic trade flows, but also intra-regional (*i.e.* intra-Brittany and intra-Rest of France), and inter-regional (*i.e.* trade between Brittany and the rest of France) trade data were missing for the modelling. We construct these data using observed data [28] and the structure of the model.

In order to check the robustness of our predicted trade data, comparison with direct, even partial data would be helpful. Unfortunately, such data were not available. The only relevant numbers we can use were the regional agri-food industry turnover and French transport data. Based on them we conclude that our original computations of intra- and inter-regional data were underestimated. To overcome this underestimation and correct the flows we impose an additional hypothesis that computed and observed trade data yield

28. Regional customs data, *i.e.* Brittany imports and exports to foreign countries. These data also have some limitations. For instance, they take into account the place of export to foreign countries, not of production, which can lead to over or underestimate the real trade flows.

a border effect equal to the one estimated by Olper and Raimondi (2008a). The border effect measures the extent to which the volume of domestic trade exceeds the volume of international trade. We estimate a border effect of 6.3 at the aggregate level [29] with the method of Olper and Raimondi (2008a). This value is lower than the one generally estimated in the literature. We multiply the flows by a factor of 4.87 to reach a border effect of 30.57. Despite the underestimation, this chapter constitutes a methodological contribution aiming to compensate for a lack of regional data and pave the way for more regional studies.

Concerning the choice of elasticity we set the value at 7 for all groups, except for the *"Meat and meat products"* category, for which we set it equal to 10 for unilateral liberalization of the British market, and 9 for the other scenarios. 7 is the smallest value for which almost all groups and all scenarios converge. For robustness, we compare results with the ones obtained with a value of 5 (when possible) and 9 for the elasticity of substitution. Even if our results remain dependent on the estimated or setted elasticity of substitution, we temper this limitation by giving the results in function of the chosen elasticity.

Comparing Brittany to the rest of France, we find very close results in terms of percentages of loss, by product category. The most significant losses are made for the scenarios of liberalization of the British market; the WTO rules applied to all UK partners; or just applied to the EU partners combined with a PTA with main non-EU partners. In addition, concerning the variations in Brittany's exports to the UK, some groups are not sensitive to changing scenarios, for example *"Other alcoholic drinks"* (around -0.06 million euros), *"Cereals and cereal products"* (between -1.93 and -2.09 million euros), and *"Oils and fats"* (between -0.19 and -0.28 million euros).

In value, the greatest losses are caused for the group of *"Meat and meat products"* (-61.19 millions euros in destination to the UK, for the scenario of the liberalization of the British market). Meat is the number one product group exported from Brittany to the UK, so it's not surprising that it's impacted so heavily. But for this group we set a higher elasticity, and therefore the effects can be amplified. By setting aside this case, the category of *"Fruits and vegetables"* is strongly affected under the scenario of the WTO rules applied to all UK partners, but to a lesser extent (-8.20 million euros), so are the *"Dairy products"* (-5.01 million euros). To sum up, we expect particularly high losses for the flagship products of Breton exports, such as meat products, fruits, vegetables, dairy products, and to a lesser extent, seafood and cereals.

Chapter IV focuses on Irish exports to France. We aimed to highlight the post-Brexit potential higher cost of using of the land-bridge route from Ireland through the UK to access the mainland EU. Ignoring this aspect may have led previous studies to underestimate the

29. This means that domestic trade is 6.3 times greater than that between two countries.

magnitude of Brexit impacts on Irish exports. Similarly to **Chapter III**, to address this question, precise data were needed but missing, namely the transport costs by mode and modal shares at a disaggregated level, for intra EU trade. We constructed the missing data, using observed data. We predict modal-specific freight costs (ad-valorem trade cost or AVTC) following procedure from Hummels et al. (2014), and the modal shares for each trade flow, using a multinomial fractional logit (MFL) model.

The predicted maritime freight costs don't vary much (2.06% – 3.82% of ad-valorem *"Free On Board"* value, AVTC), contrary to the road freight costs (7.99% – 122.69%). Restraining the sample to the intra EU trade, these ranges are respectively: 2.15% – 3.63% and 7.99% – 57.55%. The road freight costs are much higher than the sea ones. Yet, the road mode is widely used, which confirmed that the road choice bring other benefits than freight rate: a lower time cost.

We then estimated the marginal effects of transport costs on modal shares, *i.e.* the modal substitution effects, or modal report. Among the transport costs (explanatory variables), we chose the mode-specific AVTC ratio (road over sea), but also distances ratio and squared distances ratio, as proxies for the relative time costs. The main results suggest that a one unit increase in the ratio of the AVTC (*e.g.* the road freight costs double) makes the share of road fall of approximately 4%, at the mean sample point. The two time cost proxies have opposite effects in most of the cases (both an increase and a decrease in the sea share). A conceivable explanation is that a modal report from road to sea will generate a higher activity in the maritime route. This activity can increase congestion and, as a consequence, time costs. This, in turn may also raise final transport costs and hence have a negative effect on the sea share. Estimating the marginal effects chapter by chapter, we observe differenciated impacts of the time costs. We assume the products characteristics, such as their perishability, plays a role. For instance, we do not observe a massive modal report from road to sea for the groups *"Fish and crustaceans"* and *"Cereals"*, which are, according to our hypothesis, particularly sensitive to the time cost.

Finally, we proposed to assess the land-bridge effect on Irish trade using a traditional gravity model. We assumed that freights costs (direct and time) determine new modal shares. We used the sea share as one of the explanatory variables in a standard gravity model, with the trade value (all modes confounded) as dependant variable. We do find the traditional effects of gravity equations, *i.e.* a positive effect on trade flows if the two countries have a common border, or a common language, or a common colonial past. Tariffs have a negative impact on trade flows, and the NTM regulatory distance is not significant. As expected, a larger sea share has a negative effect on the total trade flows, which is probably due to the higher travel time associated to the sea mode. An increase of 10% of the sea share generates a decrease in the traded value of 0.32 – 0.62%. This is an additional

effect of Brexit that is usually omitted in the Brexit literature, leading to underestimations of the Brexit impacts on Ireland. In **Chapter II**, Ireland was identified as the first loosing country among the EU members, and yet the land-bridge costs were not included.

These results have several implications but also some limitations that can guide future research in the field. Similarly to **Chapter III**, we built an indirect database to compensate for the lack of direct data, but while comparison with direct, even partial data would be helpful such data were not available. In addition, the primary data we use either to construct secondary data or as inputs in models have some important limitations. For instance, data giving modal share are based on the mode entered when leaving the country, which is not necessarily the main mode, which would be a more relevant information.

Heeding more details concerning each mode would be relevant but could hardly be performed at a disaggregated level. For instance, concerning the maritime mode, two loading methods, or operating systems, are available, namely RoRo (Roll on/Roll off) and LoLo (Lift on/Lift off). These two methods entail different costs, both in terms of time and money. In addition, for each transport mode, it would be relevant to introduce fixed costs depending on the countries considered.

2 Further considerations: extensions

In this section we first propose some possible extensions, deepening, or further work to complete and continue our current work, and second a more general opening about integration, governance and common goods.

2.1 Possible extensions

Our literature review in **Chapter I** revealed that the development of innovative methods for evaluating disintegration would be eagerly useful. The current method, consisting in treating disintegration as the reverse of integration, is not fully satisfying, and not suitable for some kinds of trade costs.

An interesting deepening of our current work would be the consolidation of the data prediction approaches by encouraging the collection of data in order to conduct relevant comparisons. In particular, inter-regional and intra-regional trade data (*cf.* **Chapters II and III**) or precise Irish trade data, by transport mode, in value and volume (*cf.* **Chapter IV**) would allow a relevant comparison with our estimated results and improve the robustness of our approach.

The same modelling framework we used for Brittany could be applied to other French regions, but also, with some ajustements, to split the UK into the Northern Ireland and the

Great Britain, in order to refine the Irish (Republic of Ireland) trade impacts assessment.

Another planned extension of the study on Ireland and the UK land-bridge consists in introducing precise scenarios using, among others, variations of modal shares, time costs and freight costs. In orther words, we aim to perform a real-world simulation with our model, *i.e.* find out what percentage the land-bridge travel time roughly increase through Brexit, adapt it to our distance and squared distance ratios, and predict new sea shares. Once we obtain new sea shares under different scenarios, depending on the outcomes of the negociations, we can also assume corresponding tariffs, NTM distance or other explanatory variables under the different scenarios. With our gravity model we can predict the change in bilateral trade flows, *i.e.* Irish exports to France, but also Irish exports to other EU countries, under the different scenarios.

Finally, environnemental indexes could be associated to each transport mode considered in addition to trade variation, as an extention of the **Chapter IV**. One could assess, for example, carbon dioxyde consumption variation associated to a modal report or a variation in trade flows following a policy change.

In the next section we aim to address some additional political and global questions, in connection with the potential new disintegration wave evoked in **Chapter I**.

2.2 Globalization and governance in the global crises: future of the EU

In **Chapter I** we questioned what will be the impact of Brexit on the future of the EU. We highlighted from the literature that one of the reasons for the Brexit vote was the tension between national sovereignty and supra-national governance, resulting from integration, and more broadly globalization. As a consequence, since globalization still seems to be on the political agenda, Brexit could mark the beginning of a new EU disintegration period.

To qualify this hypothesis and fuel the discussion, we point another aspect in connection with both globalization and governance, namely the tragedy of the ***"global commons"***, leading to global crises. This term denotes areas and natural resources that are not subject to the national jurisdiction of a particular state but are shared by several states, if not the international community as a whole (Buck, 1998). The high seas, the deep seabed, as well as certain global natural assets, such as the climate system, the air, water, seeds, winds and sunshine, can be viewed as global commons because no national entity can claim sole jurisdiction over these physical areas. As both viruses and greenhouse gases know no borders, unpolluted air and global health are considered as global commons. The risk linked to the use of these shared-resources is their destruction due to overuse, such as in over-fishing.

Economic integration plays a role in global commons depletion and global crises, via different channels, including the growth of resource consumption and pollution due to the thermo-industrial model, and the quick spread of diseases and viruses, with intense interconnections and exchanges around the world, leading to health crises, or even pandemics such as COVID-19. In addition to integration, poor or unsuitable **governance** is another reason for global crises. Either states have to regulate themselves, either global agreements have to be settled, in order to manage the large-scale resources, *i.e.* the global commons [30] and preserve the freedom of access for the benefit of all (Schrijver, 2016). But these areas and resources are beyond the sovereignty of any state and their good management can be reached only through international cooperation. As a result, even if different levels of governance are possible (from local to supra-national), a global strategy would avoid deviant individual behaviors (of people or states) and would lead to an optimal situation for everyone. To sum up, it seems that global problems need global responses, *i.e.* a global governance and adequate supranational structures, [31] but the diversity of individual interests makes the implementation of such governance quite hard in practice.

The recent COVID-19 and the climate change crises highlight the difficulty of a global governance, whereas local levels, though necessary, are not enough to manage global commons. In addition to an empowered local leadership, a strengthened multilevel governance system is needed. [32] Yet, in the past, people have been able to gather around ideas such as human rights, especially in response to major crises, at global level (*e.g.* the World War II and the creation of the United Nations organizations to maintain peace).

This context of global crises and the need for improved management and preservation of global commons can be an opportunity to give another meaning to the EU and reinforce cohesion between members. The supra-national governance at the EU level could be strengthened, not necessarily in every field, but at least in the management of global common goods, and keeping in mind the importance of respecting specificities, cultural differences and feelings of belonging and to find a common value basis for governance.

To conclude, on the one hand, if economic integration keep fuelling the tension between local sovereignty and supra-national governance, Brexit could be the first episode of a disinteration period. On the other hand, facing global crises, economic integration could provide an efficient level of governance for global commons. From this angle, Brexit could represent only an isolated event of disintegration, an integration retract only to jump higher.

30. For instance unpolluted air, global health but also other transboundary pollution and tropical deforestation.
31. https://www.democracywithoutborders.org
32. As the COVID-19 crisis is very recent, few papers do exist at the moment, but the link between the levels of common goods governance and COVID-19 is treated in the daily press, here are some examples: https://youmatter.world; https://www.baselgovernance.org; http://medanthroquarterly.org; https://www.cfr.org; https://probonoaustralia.com.au; https://www.democracywithoutborders.org.

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Bibliography

Abalain, H. (2000). *Histoire de la langue bretonne*, Volume 10. Editions Jean-Paul Gisserot.

Agnosteva, D. E., J. E. Anderson, and Y. V. Yotov (2014). Intra-national trade costs: Measurement and aggregation. Technical report, National Bureau of Economic Research.

Agnosteva, D. E., J. E. Anderson, and Y. V. Yotov (2019). Intra-national trade costs: Assaying regional frictions. *European Economic Review 112*, 32–50.

Alesina, A., E. Spolaore, and R. Wacziarg (2000). Economic integration and political disintegration. *American Economic Review 90*(5), 1276–1296.

Anderson, J. E. (1979). A theoretical foundation for the gravity equation. *American Economic Review 69*(1), 106–116.

Anderson, J. E., M. Larch, and Y. V. Yotov (2018). GEPPML: General equilibrium analysis with PPML. *The World Economy 41*(10), 2750–2782.

Anderson, J. E. and E. Van Wincoop (2003). Gravity with gravitas: A solution to the border puzzle. *American economic review 93*(1), 170–192.

Anderson, J. E. and E. Van Wincoop (2004). Trade costs. *Journal of Economic Literature 42*(3), 691–751.

Anderson, J. E. and Y. V. Yotov (2010). The changing incidence of geography. *American Economic Review 100*(5), 2157–2186.

Arkolakis, C., A. Costinot, and A. Rodríguez-Clare (2012). New trade models, same old gains? *American Economic Review 102*(1), 94–130.

Arriola, C., C. Carrico, D. Haugh, N. Pain, E. Rusticelli, D. Smith, F. van Tongeren, and B. Westmore (2018). The potential macroeconomic and sectoral consequences of Brexit on Ireland. Working Paper 1508, OECD.

Baier, S. L. and J. H. Bergstrand (2007). Do free trade agreements actually increase members' international trade? *Journal of International Economics 71*(1), 72–95.

Baier, S. L., J. H. Bergstrand, and M. Feng (2014). Economic integration agreements and the margins of international trade. *Journal of International Economics 93*(2), 339–350.

Bajzik, J., T. Havranek, Z. Irsova, and J. Schwarz (2020). Estimating the armington elasticity: The importance of study design and publication bias. *Journal of International Economics*, 103383.

Balassa, B. (1961). The theory of economic integration. *Inc. London*.

Baldwin, R. and D. Taglioni (2006). Gravity for dummies and dummies for gravity equations. Working Paper 12516, National Bureau of Economic Research.

Baldwin, R. E. and A. J. Venables (1995). Regional economic integration. *Handbook of international economics 3*, 1597–1644.

Barrett, A., A. Bergin, J. FitzGerald, D. Lambert, D. McCoy, E. Morgenroth, I. Siedschlag, and Z. Studnicka (2015). *Scoping the possible economic implications of Brexit on Ireland*. Economic and Social Research Institute Dublin.

Bellora, C., C. Emlinger, J. Fouré, and H. Guimbard (2017). *Research for AGRI Committee-EU-UK Agricultural Trade: State of Play and Possible Impacts of Brexit: Study*. European Parliament.

Bénabou, R. and J. Tirole (2016). Mindful economics: The production, consumption, and value of beliefs. *Journal of Economic Perspectives 30*(3), 141–164.

Berden, G., J. Francois, M. Thelle, P. Wymenga, and S. Tamminen (2009). Non-tariff measures in EU-US trade and investment – an economic analysis. *ECORYS*.

Bergin, A., A. Garcia-Rodriguez, E. L. Morgenroth, and D. Smith (2017). Modelling the medium-to long-term potential macroeconomic impact of Brexit on Ireland. *The Economic and Social Review 48*(3, Autumn), 305–316.

Bergstrand, J. H. (1985). The gravity equation in international trade: Some microeconomic foundations and empirical evidence. *The Review of Economics and Statistics*, 474–481.

Bergstrand, J. H. (1989). The generalized gravity equation, monopolistic competition, and the factor-proportions theory in international trade. *The Review of Economics and Statistics*, 143–153.

Bernard, A. B., J. Eaton, J. B. Jensen, and S. Kortum (2003). Plants and productivity in international trade. *American Economic Review 93*(4), 1268–1290.

Bisciari, P. (2019). A survey of the long-term impact of Brexit on the UK and the EU27 economies. Technical Report 366, NBB Working Paper.

Born, B., G. J. Müller, M. Schularick, and P. Sedláček (2019). The costs of economic nationalism: evidence from the Brexit experiment. *The Economic Journal 129*(623), 2722–2744.

Bradley, D. and B. Hill (2019). Quantitative modelling for post-Brexit scenarios. *Final report for AHDB, Agribusiness Consulting| Informa. Updated*, 232.

Brakman, S., H. Garretsen, and T. Kohl (2018). Consequences of Brexit and options for a "Global Britain". *Papers in Regional Science 97*(1), 55–72.

Breen, B., P. Brewster, C. O' Driscoll, and A. Tsakiridis (2018). The implications of Brexit on the use of the landbridge. Technical report, Irish Maritime Development Office.

Brun, J.-F., C. Carrère, P. Guillaumont, and J. De Melo (2005). Has distance died? evidence from a panel gravity model. *The World Bank Economic Review 19*(1), 99–120.

Bruno, R. L., N. Campos, S. Estrin, and M. Tian (2017). Economic integration, foreign investment and international trade: The effects of membership of the European Union. Discussion Paper 1518, Centre for Economic Performance, London School of Economics and Political Science.

Buch, C. M. and F. Toubal (2009). Openness and growth: The long shadow of the berlin wall. *Journal of Macroeconomics 31*(3), 409–422.

Buck, S. J. (1998). *The global commons: An introduction*. Island Press.

Byrne, S., J. Rice, et al. (2018). Non-tariff barriers and goods trade: A Brexit impact analysis. Technical report, Central Bank of Ireland.

Cadot, O., A. Asprilla, J. Gourdon, C. Knebel, and R. Peters (2015). *Deep regional integration and non-tariff measures: A methodology for data analysis*. UN.

Cadot, O., J. Gourdon, and F. van Tongeren (2018). Estimating ad valorem equivalents of non-tariff measures. OECD Trade Policy Papers 215.

Campos, N. F., F. Coricelli, and L. Moretti (2014). Economic growth and political integration: Estimating the benefits from membership in the European Union using the synthetic counterfactuals method. IZA Discussion Paper No. 8162.

Campos, N. F., F. Coricelli, and L. Moretti (2015). Norwegian rhapsody? the political economy benefits of regional integration. CEPR Discussion Paper No. DP10653.

Capello, R., A. Caragliu, and U. Fratesi (2018). The regional costs of market size losses in a EU dismembering process. *Papers in Regional Science 97*(1), 73–90.

Cappariello, R., M. Damjanovic, M. Mancini, and F. Vergara Caffarelli (2018). EU-UK global value chain trade and the indirect costs of Brexit. *Bank of Italy Occasional Paper* (468).

CESER (2016). Et après ? les enjeux du Brexit pour la Bretagne. Technical report.

CESER (2017). Les conséquences socio-économiques potentielles du Brexit dans les régions de la façade atlantique française. Technical report.

Chaney, T. (2008). Distorted gravity: the intensive and extensive margins of international trade. *American Economic Review 98*(4), 1707–1721.

Chen, W., B. Los, P. McCann, R. Ortega-Argilés, M. Thissen, and F. van Oort (2018). The continental divide? economic exposure to Brexit in regions and countries on both sides of the Channel. *Papers in Regional Science 97*(1), 25–54.

Cheptea, A. and M. Huchet (2019). Will a no-deal Brexit disturb the EU-UK agri-food trade? *EuroChoices 18*(2), 28–36.

Cheptea, A., M. Huchet, and L. Henry (2020). How will Brexit affect the patterns of European agricultural and food exports? mimeo.

Clark, X., D. Dollar, and A. Micco (2004). Port efficiency, maritime transport costs, and bilateral trade. *Journal of development economics 75*(2), 417–450.

Copenhagen Economics (2018). Ireland and the impacts of Brexit. *Dublin: Department of Business, Enterprise and Innovation*.

Costa, R. and S. Machin (2017). Real wages and living standards in the UK. *CEP Election Analysis 36*.

Costinot, A. and A. Rodríguez-Clare (2014). Trade theory with numbers: Quantifying the consequences of globalization. In *Handbook of International Economics*, Volume 4, pp. 197–261. Elsevier.

Crafts, N. (2016). The growth effects of EU membership for the UK: a review of the evidence. *University of Warwick CAGE Working Paper 280*.

Davis, J., S. Feng, M. Patton, J. Binfield, et al. (2017). Impacts of alternative post-Brexit trade agreements on UK agriculture sector analyses using the FAPRI UK model. Agri-Food and Biosciences Institute.

De Ménil, G. and M. Maurel (1994). Breaking up a customs union: The case of the austro-hungarian empire in 1919. *Review of World Economics 130*(3), 553–575.

Deardorff, A. V. (2014). *Terms of trade: glossary of international economics*. World Scientific.

Dhingra, S., H. Huang, G. Ottaviano, J. Paulo Pessoa, T. Sampson, and J. Van Reenen (2017). The costs and benefits of leaving the EU: trade effects. *Economic Policy 32*(92), 651–705.

Didier, L. and P. Koenig (2019). Has China replaced colonial trade? *Review of World Economics 155*(2), 199–226.

Disdier, A.-C. and K. Head (2008). The puzzling persistence of the distance effect on bilateral trade. *The Review of Economics and Statistics 90*(1), 37–48.

Dixit, A. K. and J. E. Stiglitz (1977). Monopolistic competition and optimum product diversity. *The American economic review 67*(3), 297–308.

Djankov, S. and C. Freund (2002). Trade flows in the former Soviet Union, 1987 to 1996. *Journal of Comparative Economics 30*(1), 76–90.

Djankov, S., C. Freund, and C. S. Pham (2010). Trading on time. *The Review of Economics and Statistics 92*(1), 166–173.

Douch, M., J. Du, and E. Vanino (2020). Defying gravity? policy uncertainty, trade destruction and diversion. *Lloyds Banking Group Centre for Business Prosperity, Research Paper No. 3*.

Douch, M., T. H. Edwards, and C. Soegaard (2018). Estimating the trade effects of the Brexit announcement shock. Warwick Economics Research Papers, 1176.

Eaton, J. and S. Kortum (2002). Technology, geography, and trade. *Econometrica 70*(5), 1741–1779.

Eaton, J., S. Kortum, and F. Kramarz (2011). An anatomy of international trade: Evidence from french firms. *Econometrica 79*(5), 1453–1498.

Erken, H., R. Hayat, C. Prins, M. Heijmerikx, and I. de Vreede (2018). Measuring the permanent costs of Brexit. *National Institute Economic Review 244*(1), R46–R55.

European Commission (2017). Joint report from the negotiators of the European Union and the united kingdom government on progress during phase 1 of negotiations under article 50 TEU on the united kingdom's orderly withdrawal from the European Union.

Fally, T. (2015). Structural gravity and fixed effects. *Journal of International Economics 97*(1), 76–85.

Feenstra, R. (2004). Advanced international trade: Theory and evidence. Princeton University Press.

Feenstra, R. C. (2018). Restoring the product variety and pro-competitive gains from trade with heterogeneous firms and bounded productivity. *Journal of International Economics 110*, 16–27.

Feenstra, R. C. and A. M. Taylor (2014). *Globalization in an age of crisis: Multilateral economic cooperation in the twenty-first century*. University of Chicago Press.

Felbermayr, G., J. K. Gröschl, and M. Steininger (2018). Quantifying Brexit: From ex post to ex ante using structural gravity. Technical report, CESifo Working Paper.

Fetzer, T. and C. Schwarz (2019). Tariffs and politics: Evidence from Trump's trade wars. CEPR Discussion Paper No. DP13579.

Fidrmuc, J. and J. Fidrmuc (2000). Integration, disintegration and trade in europe: Evolution of trade relations during the 1990s.

Fidrmuc, J. and J. Fidrmuc (2003). Disintegration and trade. *Review of International Economics 11*(5), 811–829.

Figus, G., K. Lisenkova, P. McGregor, G. Roy, and K. Swales (2018). The long-term economic implications of Brexit for Scotland: An interregional analysis. *Papers in Regional Science 97*(1), 91–115.

Fingleton, B. (2020). Exploring Brexit with dynamic spatial panel models: Some possible outcomes for employment across the EU regions. *The Annals of Regional Science 64*(2), 455–491.

Frank, J. (2018). The effects of economic sanctions on trade: New evidence from a panel PPML gravity approach. Technical report, Hohenheim Discussion Papers in Business, Economics and Social Sciences.

Frankel, J. A. (2000). Globalization of the economy. Technical report, National Bureau of Economic Research.

Gabel, M. and H. D. Palmer (1995). Understanding variation in public support for European integration. *European Journal of Political Research 27*(1), 3–19.

García-Menéndez, L., I. Martínez-Zarzoso, and D. P. De Miguel (2004). Determinants of mode choice between road and shipping for freight transport: Evidence for four spanish exporting sectors. *Journal of Transport Economics and Policy 38*(3), 447–466.

Gasiorek, M., A. Smith, and A. J. Venables (2002). The accession of the UK to the EC: a welfare analysis. *Journal of Common Market Studies 40*(3), 425–447.

Gaulier, G., D. Mirza, S. Turban, and S. Zignago (2008). International transportation costs around the world: A new cif/fob rates dataset. *CEPII. March*, 304–324.

Gaulier, G. and S. Zignago (2010). BACI: International trade database at the product-level. the 1994-2007 version. Working Papers 2010-23, CEPII.

Gil-Pareja, S., R. Llorca-Vivero, and J. A. Martínez-Serrano (2014). Do nonreciprocal preferential trade agreements increase beneficiaries' exports? *Journal of Development Economics 107*, 291–304.

Gligorov, V. (2004). The economics of disintegration and reintegration: The case of yugoslavia. *Nationalism after communism: lessons learned*, 83–101.

Graziano, A., K. Handley, and N. Limão (2018). Brexit uncertainty and trade disintegration. Technical report, National Bureau of Economic Research.

Guillén, M. F. (2001). Is globalization civilizing, destructive or feeble? a critique of five key debates in the social science literature. *Annual Review of Sociology 27*(1), 235–260.

Hakhverdian, A., E. Van Elsas, W. Van der Brug, and T. Kuhn (2013). Euroscepticism and education: A longitudinal study of 12 EU member states, 1973–2010. *European Union Politics 14*(4), 522–541.

Harrigan, J. and A. J. Venables (2006). Timeliness and agglomeration. *Journal of Urban Economics 59*(2), 300–316.

Head, K. and T. Mayer (2013). What separates us? sources of resistance to globalization. *Canadian Journal of Economics 46*(4), 1196–1231.

Head, K. and T. Mayer (2014). Gravity equations: Workhorse, toolkit, and cookbook. In *Handbook of International Economics*, Volume 4, pp. 131–195. Elsevier.

Head, K., T. Mayer, and J. Ries (2010). The erosion of colonial trade linkages after independence. *Journal of international Economics 81*(1), 1–14.

Helpman, E. (1987). Imperfect competition and international trade: Evidence from fourteen industrial countries. *Journal of the Japanese and International Economies 1*(1), 62–81.

Helpman, E. and P. R. Krugman (1985). *Market structure and foreign trade: Increasing returns, imperfect competition, and the international economy*. MIT press.

Hertel, T., D. Hummels, M. Ivanic, and R. Keeney (2007). How confident can we be of CGE-based assessments of free trade agreements? *Economic Modelling 24*(4), 611–635.

Hertz, R. and D. Leuffen (2011). Too big to run? analysing the impact of enlargement on the speed of eu decision-making. *European Union Politics 12*(2), 193–215.

Hiscox, M. J. (2003). Political integration and disintegration in the global economy. *Globalizing Authority*.

HM Treasury (2016a). HM treasury analysis: The immediate economic impact of leaving the EU.

HM Treasury (2016b). HM treasury analysis: The long-term impact of EU membership and the alternatives.

Hobolt, S. B. and C. E. De Vries (2016). Public support for European integration. *Annual Review of Political Science 19*, 413–432.

Holobiuc, A.-M. et al. (2018). The analysis of the economic impact of Brexit on the European Union. In *Institute for Economic Forecasting Conference Proceedings*, Number 180502. Institute for Economic Forecasting.

Hooghe, L. (2007). What drives euroskepticism? party-public cueing, ideology and strategic opportunity. *European Union Politics 8*(1), 5–12.

Hornok, C. and M. Koren (2017). Winners and losers of globalization: Sixteen challenges for measurement and theory. *Economics without Borders*, 238–273.

Hummels, D. (2001a). Time as a trade barrier. *Unpublished Manuscript, Purdue University*.

Hummels, D. (2001b). Toward a geography of trade costs. *GTAP Working Papers* (1162).

Hummels, D. (2003). Have international transportation costs declined? mimeo.

Hummels, D. (2007). Transportation costs and international trade in the second era of globalization. *Journal of Economic Perspectives 21*(3), 131–154.

Hummels, D., R. Jørgensen, J. Munch, and C. Xiang (2014). The wage effects of offshoring: Evidence from danish matched worker-firm data. *American Economic Review 104*(6), 1597–1629.

Hummels, D. and A. Skiba (2004). Shipping the good apples out? an empirical confirmation of the alchian-allen conjecture. *Journal of Political Economy 112*(6), 1384–1402.

Hummels, D. L. and G. Schaur (2013). Time as a trade barrier. *American Economic Review 103*(7), 2935–1959.

Hynes, W., D. S. Jacks, and K. H. O'rourke (2012). Commodity market disintegration in the interwar period. *European Review of Economic History 16*(2), 119–143.

Imbs, J. and I. Mejean (2017). Trade elasticities. *Review of International Economics 25*(2), 383–402.

Inglehart, R. (1970). Cognitive mobilization and European identity. *Comparative Politics 3*(1), 45–70.

Irarrazabal, A., A. Moxnes, and L. D. Opromolla (2015). The tip of the iceberg: A quantitative framework for estimating trade costs. *Review of Economics and Statistics 97*(4), 777–792.

Jacks, D. S., C. M. Meissner, and D. Novy (2008). Trade costs, 1870-2000. *American Economic Review 98*(2), 529–534.

Jacks, D. S. and D. Novy (2020). Trade blocs and trade wars during the interwar period. *Asian Economic Policy Review 15*(1), 119–136.

Jafari, Y. and W. Britz (2018). Modelling heterogeneous firms and non-tariff measures in free trade agreements using computable general equilibrium. *Economic Modelling 73*, 279–294.

Jafari, Y. and W. Britz (2020). Brexit–an economy-wide impact assessment looking into trade, immigration, and foreign direct investment. *Empirica 47, 17–52*.

Kahneman, D. (2011). *Thinking, fast and slow*. Macmillan.

Keogh, G. (2018). A gravity model analysis of Irish merchandise goods exports under Brexit. arXiv preprint arXiv:1812.08591.

Kierzenkowski, R., N. Pain, E. Rusticelli, and S. Zwart (2016). The economic consequences of Brexit: a taxing decision. OECD Economic Policy Papers 16, OECD Publishing.

Kirby, A. (2017). Brexit: A sectoral overview. Technical report, Irish Government Economic and Evaluation Service.

Korinek, J. and P. Sourdin (2009). Clarifying trade costs: Maritime transport and its effect on agricultural trade. OECD Trade Policy Working Paper No. 92.

Krastev, I. (2012). European disintegration?: A fraying union. *Journal of Democracy 23*(4), 23–30.

Krugman, P. (1980). Scale economies, product differentiation, and the pattern of trade. *American Economic Review 70*(5), 950–959.

Krugman, P. (1995). Increasing returns, imperfect competition and the positive theory of international trade. *Handbook of International Economics 3*, 1243–1277.

Larue, B. (2018). Economic integration reconsidered. *Canadian Journal of Agricultural Economics 66*(1), 5–25.

Lavery, S., S. McDaniel, and D. Schmid (2019). Finance fragmented? Frankfurt and Paris as European financial centres after Brexit. *Journal of European Public Policy 26*(10), 1502–1520.

Lawless, M. and E. L. Morgenroth (2017). Ireland's international trade and transport connections. Technical report, ESRI Working Paper.

Lawless, M. and E. L. Morgenroth (2019). The product and sector level impact of a hard Brexit across the EU. *Contemporary Social Science 14*(2), 189–207.

Leamer, E. E. and J. Levinsohn (1995). International trade theory: The evidence. *Handbook of international economics 3*, 1339–1394.

Leconte, C. (2010). *Understanding euroscepticism*. Macmillan international Higher Education.

Limao, N. and A. J. Venables (2001). Infrastructure, geographical disadvantage, transport costs, and trade. *The World Bank Economic Review 15*(3), 451–479.

Looi Kee, H., A. Nicita, and M. Olarreaga (2009). Estimating trade restrictiveness indices. *The Economic Journal 119*(534), 172–199.

Marcias, M. (2015). *Accès aux marchés étrangers, l'impact de la localisation et des modes de transport sur les performances à l'exportation des firmes agroalimentaires françaises*. Ph. D. thesis.

Margalit, Y. (2012). Lost in globalization: International economic integration and the sources of popular discontent. *International Studies Quarterly 56*(3), 484–500.

Marković, I. and M. Đokić (2018). Effects of international economic disintegration in the case of Brexit. *TEME*, 541–560.

Martin, P., T. Mayer, and M. Thoenig (2012). The geography of conflicts and regional trade agreements. *American Economic Journal: Macroeconomics 4*(4), 1–35.

Matthews, A. (2017a). Brexit impacts on Irish agri-food exports to the UK. *EuroChoices 16*(2), 26–32.

Matthews, A. (2017b). *Research for AGRI committee – Possible transitional arrangements related to agriculture in the light of the future EU-UK relationship: Institutional issues: Study*. European Parliament.

Matthews, A. (2018). Implications of Brexit for food and agriculture in developing countries. *Trinity Economic Papers* (0318).

Mattoo, A., A. Mulabdic, and M. Ruta (2017). *Trade creation and trade diversion in deep agreements*. The World Bank.

Maurel, M. and G. Cheikbossian (1998). The new geography of eastern European trade. *Kyklos 51*(1), 45–72.

Mayer, T., V. Vicard, and S. Zignago (2019). The cost of non-europe, revisited. *Economic Policy 34*(98), 145–199.

Mayer, T. and S. Zignago (2011). Notes on CEPII's distances measures: The geodist database. Working Papers 2011-25, CEPII.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica 71*(6), 1695–1725.

Miao, G. and F. Fortanier (2017). Estimating transport and insurance costs of international trade. OECD Statistics Working Papers, n° 2017/04.

Milanovic, B. (2002). Unexpected convergence: Disintegration of world economy 1919-39, and income convergence among rich countries. *World Bank Working Paper*.

Morgan, J., J. Tumlinson, and F. Várdy (2020). Bad trade: The loss of variety. *SSRN 3529246*.

Mulabdic, A., A. Osnago, and M. Ruta (2017). *Deep integration and UK-EU trade relations*. The World Bank.

Mullahy, J. (2015). Multivariate fractional regression estimation of econometric share models. *Journal of Econometric Methods 4*(1), 71–100.

Nitsch, V. and N. Wolf (2013). Tear down this wall: on the persistence of borders in trade. *Canadian Journal of Economics 46*(1), 154–179.

Nordås, H. K. and R. Piermartini (2004). Infrastructure and trade.

Novy, D. (2013). Gravity redux: Measuring international trade costs with panel data. *Economic inquiry 51*(1), 101–121.

Oberhofer, H. and M. Pfaffermayr (2018). Estimating the trade and welfare effects of Brexit: A panel data structural gravity model. CESifo Working Paper Series No. 6828.

Oberhofer, H., M. Pfaffermayr, and R. Sellner (2018). Revisiting time as a trade barrier: Evidence from a panel structural gravity model. CESifo Working Paper, No. 7426.

OECD (2016). The economic consequences of Brexit: A taxing decision.

Olper, A. and V. Raimondi (2008a). Explaining national border effects in the QUAD food trade. *Journal of Agricultural Economics 59*(3), 436–462.

Olper, A. and V. Raimondi (2008b). Market access asymmetry in food trade. *Review of World Economics 144*(3), 509–537.

Papke, L. E. and J. M. Wooldridge (1996). Econometric methods for fractional response variables with an application to 401 (k) plan participation rates. *Journal of Applied Econometrics 11*(6), 619–632.

Power, A. (2018). Addressing the skills needs arising from the potential trade implications of Brexit. Expert Group on Future Skills Needs, Dublin.

Raimondi, V. and A. Olper (2009). The sensitivity of trade flows to trade barriers.

Rho, S. and M. Tomz (2017). Why don't trade preferences reflect economic self-interest? *International Organization 71*(S1), S85–S108.

Rodrik, D. (2000). How far will international economic integration go? *Journal of Economic Perspectives 14*(1), 177–186.

Rodrik, D. (2011). *The globalization paradox: democracy and the future of the world economy*. WW Norton & Company.

Rodrik, D. (2018). Populism and the economics of globalization. *Journal of International Business Policy 1*(1-2), 12–33.

Rojas-Romagosa, H. (2016). *Trade effects of Brexit for the Netherlands*. CPB Netherlands Bureau for Economic Policy Analysis.

Rose, A. K. and C. Engel (2000). Currency unions and international integration. Technical report, National Bureau of Economic Research.

Sampson, T. (2017). Brexit: The economics of international disintegration. *Journal of Economic Perspectives 31*(4), 163–184.

Samuelson, P. A. (1954). The transfer problem and transport costs, ii: Analysis of effects of trade impediments. *The Economic Journal 64*(254), 264–289.

Sánchez-Cuenca, I. (2000). The political basis of support for European integration. *European Union Politics 1*(2), 147–171.

Santeramo, F. G. and E. Lamonaca (2019). The effects of non-tariff measures on agri-food trade: A review and meta-analysis of empirical evidence. *Journal of Agricultural Economics 70*(3), 595–617.

Sapir, A. (2012). European integration at the crossroads: A review essay on the 50th anniversary of bela balassa's theory of economic integration. *Journal of Economic Literature 49*(4), 1200–1229.

Schrijver, N. (2016). Managing the global commons: Common good or common sink? *Third World Quarterly 37*(7), 1252–1267.

Schürenberg-Frosch, H. (2015). We could not care less about armington elasticities–but should we? a meta-sensitivity analysis of the influence of armington elasticity misspecification on simulation results. *Ruhr Economic Paper* (594).

Silva, J. S. and S. Tenreyro (2006). The log of gravity. *The Review of Economics and Statistics 88*(4), 641–658.

Silva, J. S. and S. Tenreyro (2011). Further simulation evidence on the performance of the poisson pseudo-maximum likelihood estimator. *Economics Letters 112*(2), 220–222.

Simionescu, M. (2018). The impact of European economic integration on migration in the European Union. *HOLISTICA–Journal of Business and Public Administration 9*(1), 23–34.

Sivakumar, A. and C. Bhat (2002). Fractional split-distribution model for statewide commodity-flow analysis. *Transportation Research Record 1790*(1), 80–88.

Smith, A. (1776). *The wealth of nations*, Volume 4. W. Strahan and T. Cadell, London.

Tinbergen, J. (1962). Shaping the world economy; suggestions for an international economic policy. New York: Twentieth Century Fund.

Van Berkum, S., R. Jongeneel, M. Van Leeuwen, and I. Terluin (2018). *Exploring the impacts of two Brexit scenarios on Dutch agricultural trade flows*. Number 2018-026. Wageningen University & Research, BU Glastuinbouw.

Van Berkum, S., R. Jongeneel, H. Vrolijk, M. Van Leeuwen, and J. Jager (2016). *Implications of a UK exit from the EU for British agriculture: study for the National Farmers' Union (NFU), Warwickshire, UK*, Volume 2016. Lei Wageningen UR.

Vicard, V. (2012). Trade, conflict, and political integration: Explaining the heterogeneity of regional trade agreements. *European Economic Review 56*(1), 54–71.

Vujacic, V. and V. Zaslavsky (1991). The causes of disintegration in the USSR and yugoslavia. *Telos 1991*(88), 120–140.

Walter, T. (2018). Trade and welfare effects of a potential free trade agreement between japan and the united states. Technical report, Hohenheim Discussion Papers in Business, Economics and Social Sciences.

West, G. E., C. Gendron, B. Larue, and R. Lambert (2002). Consumers' valuation of functional properties of foods: Results from a canada-wide survey. *Canadian Journal of Agricultural Economics 50*(4), 541–558.

Yotov, Y. V., R. Piermartini, J.-A. Monteiro, and M. Larch (2016). *An advanced guide to trade policy analysis: The structural gravity model*. World Trade Organization Geneva.

Yu, W., C. Elleby, K. M. H. Lind, and M. N. Thomsen (2017). *Modeling the potential impacts of two Brexit scenarios on the Danish agricultural sectors*. Department of Food and Resource Economics, University of Copenhagen.

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AGRO CAMPUS OUEST

Titre : Études sur l'impact du Brexit sur le commerce agricole et alimentaire: une perspective européenne et un focus sur la région Bretagne et l'Irlande.

Mots clés : Commerce international, politique agricole et commerciale, désintégration économique, Brexit

Résumé : Le Brexit est un cas de désintégration économique sans précédent qui soulève de nombreuses questions autour de ses potentielles futures conséquences économiques. Cette thèse a pour ambition d'identifier les défis post-Brexit auxquels seront confrontés les producteurs européens en matière de commercialisation des produits agricoles et alimentaires. Nous commençons par une revue de la littérature de l'intégration et la désintégration économique. Nous nous demandons comment sont traitées l'intégration et la désintégration dans la littérature, et si le Brexit représente le premier épisode d'une vague de désintégration en Union Européenne ou un cas isolé dans l'intégration croissante post-1945. À l'aide des modèles de gravité basique et structurelle, nous identifions les filières françaises les plus affectées, notamment la viande et les produits laitiers. Nous nous intéressons également à l'ensemble des pays européens, avec un focus sur la région Bretagne et l'Irlande. En plus de la viande, les fruits et légumes bretons sont les filières vulnérables identifiées. Les poissons et céréales irlandais sont sensibles à l'éventuel temps de transport additionnel post-Brexit *via* l'utilisation du "*land-bridge*". Nous analysons différents scenarios sur l'aboutissement des négociations en matière de politique commerciale, non seulement entre le Royaume-Uni et l'Union Européenne, mais aussi entre le Royaume-Uni et les pays tiers. Les pays membres et le Royaume-Uni seront moins affectés si les négociations aboutissent à un accord de libre échange. Enfin, cette thèse apporte une contribution originale à la littérature sur la construction des données commerciales domestiques, régionales, mais aussi des données en lien avec les modes de transport en commerce international.

Title : Essays on the impact of Brexit on the agricultural and food trade: an European perspective and focus on the French Brittany region and Ireland.

Keywords : International trade, agricultural and trade policies, economic disintegration, Brexit

Abstract : Brexit is a case of unprecedented economic disintegration raising numerous questions around the potential future economic consequences. This thesis aims to identify the post-Brexit challenges that European producers will face in terms of agricultural and food products trade. We start with a review of how economic integration and disintegration are analyzed in the literature, and question whether Brexit is the first episode in a new wave of disintegration in the European Union or an isolated case in the growing integration post-1945. Using basic and structural gravity models, we identify the French sectors that will be most affected, including meat and dairy products. We analyze all European countries, with a focus on Ireland and the French Brittany region. In addition to meat, Brittany's fruit and vegetables are also identified as vulnerable sectors. Irish fish and cereals are sensitive to the potential post-Brexit increase in transport time *via* the "*land-bridge*". We investigate different scenarios on the outcome of trade policy negotiations, not only between the United Kingdom and the European Union, but also between the United Kingdom and third countries. Both European Union countries and the United Kingdom will be less affected if Brexit is followed by the conclusion of a free trade agreement. Finally, this thesis makes an original contribution to the literature on the construction of domestic and regional trade data, but also of data related to modes of transport in international trade.