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POLICY PAPER

Measuring the Sensitivity of the Northern Ireland Protocol on the All-Ireland Agri-Food Supply Chain

Alastair Greig*
Agri-Food Bioscience Institute, Belfast, United Kingdom

Ziping Wu
Agri-Food Bioscience Institute, Belfast, United Kingdom

Angel Aguiar
Purdue University, Indiana, United States of America

Abstract: The agri-food sectors in Northern Ireland (NI) and Ireland (IRL) have become more integrated with more investments from IRL in the north and advances in all Ireland cooperation on animal health and welfare, and disease control. However, as both jurisdictions are considered structurally similar and both have a large dairy and beef sector, they are competing in the Great Britain (GB) market for agri-food products. When considering the island of Ireland agri-food sectors in the context of Brexit and the NI Protocol, there will be clear winners and losers under different Brexit and NI protocol scenarios. What constitutes a relatively "good" economic outcome for NI farmers may come at the expense of IRL farmers, while relatively "good" economic outcomes for IRL farmers may amplify negative outcomes for NI farmers. This paper analyses the impacts of the NI Protocol in terms of what it means for the agri-food sectors in IRL, NI, but also for the island of Ireland (ISL) as a whole.

I INTRODUCTION

The Brexit agreement has now been in effect since the middle of 2021, after it had been presented to the public as the EU-UK Trade and Cooperation Agreement (EU-UK TCA). Shortly thereafter, a Northern Ireland (NI) protocol

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* Corresponding author: Alastair.greig@afbini.gov.uk

(NIP) was agreed, but – according to the European Commission[1] – not yet fully implemented as of June 2022. Among several complaints, the Commission asserts that NI exporters had not yet been completing export declarations to GB as required. The UK Government has, in turn, unilaterally introduced a NIP Protocol Bill to address "practical problems with the protocol". This will implement a two-lane system of border checks on the Irish Sea, where "trusted traders" who promise not to export from NI on to the EU will forgo checks. Generally, the UK Government has decided that NI is to experience a "dual-regulatory regime" where both UK and EU rules exist.

On paper, the nature of the changes could present significant challenges. They could potentially create a two tier system of GB exporters. A dual regulatory regime would presumably have, over time, contradictory policies and could give NI potentially competitive (dis)advantages. More generally, the NIP Bill could indicate the NIP is no longer set in stone; that the NIP is merely a precursor to further rounds of unending negotiations.

The NIP is, however, designed with the explicit policy objective of creating new Customs checks on the Irish Sea, to avoid a hard border between NI and the Republic of Ireland (IRL). In this regard, the NIP can be seen to be the product of trying to square commitments within the Belfast Agreement that ended the Troubles, which recognises the right of Irish citizens to live and work in NI, though with a commitment that NI's status in the UK post-Brexit will not be 'undermined' through significant regulatory divergence.

Within economics parlance, the NIP and NIP Bill might be interpreted as the requirement of the UK to continue to facilitate the movement of labour across NI and IRL ensuring any post-Brexit regulatory divergence between the UK and EU applies equally to NI. The agreed NIP can be seen as a compromise which keeps NI within an EU-aligned regulatory framework for goods. This paves the way for a UK-aligned regulatory framework for services in NI, which would result in a North-South hard border for services.

The NIP arrangement presents something of a crossroad from the perspective of cross-border policymaking across ISL. From the outside, NI is in a unique position, certainly in the context of the UK and IRL. The NIP, in its current form, creates an environment which may allow for the emergence of some kind of entrepôt state, "a Singapore on the Lagan" (*Belfast Telegraph*, 2018), offering new arbitrage and distribution opportunities. Alternatively, a more sceptical outlook might place NI "out in the cold", with perpetual negotiations, form-filling and/or political gridlock inhibiting NI trade with both Great Britain (GB) and the EU. Alternatively, the NIP may result in no significant changes, which would entail NI being simultaneously within the EU single market and the post-Brexit UK economy, which is the stated position of the UK Government and EU, or, at least, the intention of the NIP and/or NIP Bill.

[1] https://ec.europa.eu/commission/presscorner/detail/en/IP_22_4663 (accessed September 2022).

This paper presents impacts of these NIP scenarios as measured by economic output and predicted by a Computable General Equilibrium (CGE) model based on the Global Trade Analysis Project (GTAP) model that has been augmented with NI data. That process involved producing a five-region CGE model that encompasses NI, IRL, GB, rest of the EU (rEU) and the rest of the world (RoW). The paper, therefore, seeks to capture some measure of economic impact on the IRL and NI economies. To do so, the analysis focuses on the range of output estimates across various NIP scenarios derived from the GTAP model using ISL as a midpoint estimate between NI and IRL. In short, these results quantify the anticipated winners and losers in NI and IRL through the impact on economic output.

II ECONOMIC CONTEXT

Cross-border policymaking has a colourful recent history, at least within the Irish policy literature. There have been a great number of cross-border policies, policy proposals and initiatives established with varying degrees of attention and success. There has, however, also been an equally rich tradition of discussing these cross-border policies in less than flattering terms. Bradley and Best (2011) describe their disapproval of "old, tired jokes about smuggling" (p. 40) which were a feature in cross-border policy discourse, while Harvey (2010) describes "absurd" (p. 39) funding rules that prohibited genuine cross-border economic development.

An ISL agri-food policy, in the context of Brexit, is in a prime position to continue these two strands of cross-border policymaking. There are certainly many hypothetical opportunities from Brexit (Arnold, 2020), such as coordination between NI and IRL to both minimise arbitrage costs as well as maximising potential arbitrage income. However, it would also be "a shame to see… two very different directions, towards two very different outcomes" (Murphy, 2020, p. 145), whereby NI-IRL trade is disrupted by significantly different regulatory regimes.

The NI and IRL agri-food sectors are very similar for a variety of reasons, with a heavy focus on livestock, and in particular beef and dairy (Greig and Wu, 2021). Since the 1990s both NI and IRL agricultural policy broadly share a similar policy debate, notwithstanding some distinct features around the implementation of the Common Agricultural Policy (CAP). There is similar discussion – and similar hesitancy - around sustainable transitioning from high emitting cattle farming to more lean agricultural systems (e.g. Skinner *et al*., 1997) as well as increasing productivity (e.g. Dillon *et al*., 2008).

The overall structure of the agri-food economy of NI and IRL will stay similar to one another as both regions have similar natural, climate and social conditions. The extent to which depends on how the UK implements the NIP, as well as the degree of divergence in the long run between the UK and EU.

Pre-Brexit, the agricultural systems in the north and south of ISL were relatively integrated, shown in Table 1. This is, in a large part, due to the geographic difficulties many farmers have in moving substantial livestock numbers and raw milk over the Irish Sea, whereby raw milk and livestock cannot be easily moved by ship to GB cheaply. For similar geographical and cultural reasons, NI-IRL trade is concentrated in the areas around the ISL land border. Overall, however, NI and IRL do not trade extensively in food manufacturing products. This is, in part, due to the relative ease of shipping packaged food products. Products from NI and IRL food manufacturing firms were generally exported to third countries, and GB can be considered an important export destination.

Table 1, therefore, paints a picture of NI that is almost wholly integrated into the UK economy and the nature of IRL's agri-food economy contrasts with the rest of the IRL's economy. While the IRL economy does not export extensively to GB (around 10 per cent of total exports), GB is an important export destination for IRL agri-food (over 40 per cent of total exports), but much less so than NI. Certain key sectors in IRL agri-food economy have been heavily reliant on GB demand, and the extent this is true for all sectors is likely obfuscated, to some extent, by the disaggregation used in Table 1 (and chosen due to the GTAP database, discussed later). It follows, then, that if there was a single, integrated, pre-Brexit agri-food ISL system, it would be agricultural sectors that provide primary inputs into food manufacturing sectors for export off the island to, predominantly, GB, but also elsewhere (if produced in IRL).

III UK GOVERNMENT'S ANTICIPATED LONG-RUN NTBS FROM BREXIT

The parameterisation of border frictions in CGE models can be considered unintuitive, dependent on the choice of base year, and explicitly quantifying the increase in the level of NTBs (Non-Tariff Barriers) sometimes to two decimal places. Table 2 shows that NTBs are introduced at various levels within the CGE modelling literature.

The nature of NTBs make them difficult to estimate, even though it has long been established they are considerably more important than tariffs in terms of bilateral export and import prices (Staiger, 2012). Even after the UK-EU FTA has been agreed, it is unclear the extent of NTBs that will be encountered to goods crossing the UK-EU border arising from Brexit, or if they will ever be able to be estimated for NI. While it remains clear that the main frictions imposed from Brexit will be NTBs and not tariffs, it remains unclear at what point in the future, if at all, these costs will actually be able to be observed with accuracy, or if there will even be a long-run static 'rate' as part of stable Customs regime on the UK-EU border.

Table 1: Export Destinations for NI, IRL, and the Island of Ireland by Sector, GTAP10 Database Augmented with NI Data, 2014

	Northern Ireland			*Republic of Ireland*			*All-Ireland*	
	RoI	*GB*	*rEU*	*NI*	*GB*	*rEU*	*GB*	*rEU*
Wheat	*	*	*	71.12%	27.40%	0.42%	94.89%	1.46%
Other Cereals	*	*	*	1.00%	82.18%	3.48%	83.02%	3.52%
Vegetables	52.99%	29.26%	10.20%	28.24%	68.15%	0.96%	93.65%	2.16%
Other Crops	*	*	*	1.04%	59.15%	15.96%	59.78%	16.13%
Finished Cattle (and Sheep)	66.91%	26.11%	2.63%	15.85%	48.14%	20.14%	59.00%	22.61%
Raw Milk	100.00%	0.00%	0.00%	98.12%	0.04%	0.61%	2.28%	32.41%
Finished Pig & Poultry	16.81%	60.00%	11.94%	10.17%	37.42%	26.28%	46.92%	26.68%
Forestry	21.05%	78.95%	0.00%	10.49%	80.29%	5.79%	91.93%	5.07%
Fishing	6.52%	82.10%	8.03%	3.78%	8.80%	76.88%	20.11%	69.96%
Extraction	47.96%	46.05%	5.25%	5.74%	10.43%	53.76%	33.72%	43.30%
Beefmeat (and sheepmeat)	8.03%	78.70%	12.06%	12.49%	27.58%	54.27%	53.16%	42.43%
Pig & Poultry Meat	16.38%	71.26%	8.36%	13.15%	57.04%	17.04%	73.22%	15.91%
Dairy Products	17.27%	50.38%	20.28%	3.40%	38.20%	34.38%	44.87%	32.82%
Other Food	34.41%	57.70%	4.74%	3.40%	32.04%	20.70%	38.17%	20.14%
Drinks	9.06%	55.17%	12.81%	3.04%	20.08%	29.57%	41.81%	21.83%
Wood Products	41.86%	54.16%	2.00%	25.68%	42.13%	15.22%	66.65%	15.83%
Other Manufacturing	14.15%	37.42%	19.86%	1.53%	9.91%	37.92%	13.16%	37.09%
Utility and Construction	11.28%	82.69%	2.36%	10.91%	8.03%	20.55%	85.66%	4.49%
Transport and Communications	16.90%	56.86%	10.76%	1.09%	7.72%	34.74%	10.99%	33.96%
Other Services	14.50%	48.75%	15.47%	0.43%	5.61%	33.96%	7.77%	33.44%

Source: Data taken from NISRA's 2016 economic accounts, extended to include agri-food sectors and augmented and rebased into the GTAP 2014 database, see "data section". RoW excluded from table due to concision, as well as NI-RoW trade volumes being relatively small.

The HM Government (2018) produced its own forecast estimates of the long-run NTBs (i.e. change in trading costs) arising from the Brexit deal. These are close to zero barriers being imposed on goods (1 per cent) and central estimate of 6 per cent for services, albeit with a large variance (4 per cent). These can be considered ambitious, or "low"-end estimates.

Table 2: Scenarios Arising from Brexit Assumed in CGE Simulations, Pre-Brexit

Author	*Scenario*
Ciurak *et al*. (2017)	FTA - Rules of origin compliance cost 1 per cent, EU-UK border costs are "minimal", No NTBs, "modest" cost to cross-border services and FDI
Rojas-Romagosa (2016)	Non-Tariff Barriers, half of WTO estimates
Dhingra *et al*. (2017)	25 per cent of reducible NTBs and 75 per cent of non-reducible NTBs. This leads to NTBs of 2.77 per cent
HM Government (2018)	"Hypothetical FTA, with zero tariffs, based on estimates of average NTBs between relevant FTA partners." (p. 34) Econometrically estimated, allowing for range of estimates
Hosoe (2016)	NTBs estimated on a sector-by-sector basis
Ortiz Valverde and Latorre (2020)	A 20 per cent fall in Foreign Direct Investment
PWC (2016)	25 per cent of UK-RoW world NTBs (0.5 per cent increase in price of exports and 0.7 per cent increase in price of imports into the UK)
Rand Europe (2017)	NTBs move to 25 per cent of EU-USA NTBs (goods), increasing gradually over time (0.01/year for agriculture and 0.06/year for goods) and 75 per cent of NTBs (services)

The UK Government maintains that the TCA can be seen to reiterate its position that, at least for goods trade, the EU-UK border presents little or no long-term barriers (i.e., the UK is experiencing a "low" increase in trade costs). This was occurring while the full extent of barriers for services is not yet known. The "modelled FTA" long-run estimates (i.e. the "high" estimates), derived from a range of studies, including those in Table 3, do not draw as big a distinction between goods (+6 per cent) and service (+8 per cent) trade, but altogether assumes more severe service barriers arising from the Brexit deal.

The UK Government position, that assuming "low" frictions, has probably been partially vindicated at least for goods. Though how the increase in NTBs relates to the estimated 20 per cent reduction (Kren and Lawless, 2022) in total trade volume between the UK and EU is not clear, and so the increase in trade costs is likely variable sector-to-sector. This paper, therefore, assumes something closer to "low" NTBs now exist between GB and the EU, though this will vary sector-to-sector. The spirit of the agreed NIP is to implement a Customs border on the Irish Sea which may reduce these for NI-GB trade or, at worst, create the same trade costs EU-GB experience.

While IRL's long-run trading relationship with GB will be defined by agreement and divergence at a UK-EU level, the minutiae of the Brexit deal's NIP will define NI's. The current NIP, the one agreed by GB and the EU, places NI in the UK regulatory regime for services and the UK Customs territory for goods. While a border for goods will be implemented at the Irish Sea, this could be the source of perpetual political dispute, and it is not yet clear if it will be enforced. This arrangement places *NI within the EU* for goods, and the UK for services. There is an argument to say that NI would never be treated "just like any other EU region" by GB or "any other GB region" by the EU, though this rests on the assumption of good faith agreements between GB and the EU, which now determines NI's terms of trade. Likewise, that would suggest a *Best of Both Worlds* scenario.

Table 3: Implied Brexit-Related NTBs Assumed on NI as a Result of the NI Protocol (Low/High), Increase in Trade Costs

		NI-GB	*GB-NI*	*NI-EU*	*EU-NI*	*GB-EU*	*EU-GB*
1.	NI within EU						
	Goods	1%/8%	1%/8%	–	–	1%/8%	1%/8%
	Services	–	–	6%/9%	6%/9%	6%/9%	6%/9%
2.	Best of Both Worlds						
	Goods	–	–	–	–	–	–
	Services	–	–	6%/9%	6%/9%	6%/9%	6%/9%
3.	Asymmetric Access						
	Goods	–	1%/8%	–	–	1%/8%	1%/8%
	Services	–	–	6%/9%	6%/9%	6%/9%	6%/9%
4.	NI within UK						
	Goods	–	–	1%/8%	1%/8%	1%/8%	1%/8%
	Services	–	–	6%/9%	6%/9%	6%/9%	6%/9%

Source: Scenarios developed by HM Government (2018).

So, *NI in the EU* can be contrasted with scenarios put forward by a range of commentators and politicians which see NI being given a unique opportunity to become an intermediary between IRL and GB, by virtue of experiencing the

Best of Both Worlds, and no new barriers to trade of goods, or *Asymmetric Access*, whereby only goods moving from GB into NI have new checks. These probably more closely conform to the UK's intended implementation through the NIP 2022 Bill. The UK Government position would be that its unilateral solution offers NI the *Best of Both Worlds*, though that may be an optimistic assessment (and likely closer to *Asymmetric Access*, whereby importing to NI from GB is more difficult). Alternatively, though unlikely, the NI Protocol, in time, is revised or defaulted back to a *NI within the UK* position, and the protocol becomes closer to the original planned backstop with a notional hard border in ISL. This is less likely given current direction of travel at both an EU and UK level but may remain a proposition within NI that has some political support. This was arguably the long-run position of the proposed backstop, whereby NI would be placed within the EU regulatory system temporarily until technology facilitated a more convenient border in ISL.

IV DATA

GTAP (Global Trade Analysis Project) provides a world economic database, the "GTAP10 database" (Aguiar *et al*., 2019), which provides an input-output representation of the world economy, including 141 countries/regions. The most recent year represented is 2014. This can, therefore, represent the "pre-Brexit" position of the IRL, UK, EU and RoW. The GTAP10 database underlies the core GTAP CGE model, and provides its data structure and parameterisation. This database includes 65 sectors in each economy, although several versions of the database have been extended using various satellite information.

NI, as a region of the UK, is not included in the GTAP10 database. Despite rich public data available for NI, the primary reason for its exclusion is that GTAP is not a regional model in that it captures the interaction between nations, not the interactions within nations. Several steps are required to ensure that NI's agri-food sectors are adequately represented in the database/model.

Step one starts with incorporating Department of Agricultural, Environment and Rural Affairs (DAERA) information into the official NI regional economic accounts. The full method is detailed in Greig and Wu (2021). The main features incorporated into the official NI regional accounts include ensuring that the level of NI-produced animal feed reported in the NI feed bill is appropriately included, primary inputs into food manufacturing are properly accounted for, and to increase NI household consumption of domestically produced NI agri-food to reflect different assumed import propensities than is assumed in NI regional accounting.

[2] GTAP trade data is derived from Customs data, therefore there is no trade within a country. The estimated trade between NI and the rest of the UK is first introduced as exports from UK to UK, adjusting domestic sales in the UK to maintain balance.

Origin-destination NI trade flows, also taken from Greig and Wu (2021), had been estimated, and taken into account into our new base data.[2] To ensure the agri-food economy resembles reality, the overall structure of the NI agri-food sectors was input as hard edits (i.e. certain cells were calculated by hand based on their 2016 Leontief coefficient).

The SplitReg algorithm as described by Horridge (2011) is used to separate out NI as a new region in the GTAP database. In its simplest case, SplitReg generally apportions shares of the UK totals based on user defined weights of each NI sector. In the case of the model described here, the NI share of gross value added (GVA) was used as sector-level weights to apportion economic activity. NI origin-destination trade flows are added back into the GTAP database. The resulting NI disaggregated data structure can be seen to provide a structurally distinct GTAP-NI framework.[3]

V MODEL

GTAP also provides a CGE model (Corong *et al*., 2017), alongside numerous extensions to it, that defines the mathematical relationship between various institutions (i.e. households, firms and government). The core GTAP CGE model (Hertel, 1998) used here has been extended as proposed by Walmsley and Strutt (2019). That paper proposes a variable that can represent bilateral non-tariff trade frictions using a measure of bilateral exporter efficiency. This model was calibrated with the new GTAP-NI database.

Walmsley and Strutt (2021) discuss a number of methods to assess bilateral trade agreements (such as Brexit) presented in Table 2. Of them, two explicitly seek to model the impact of NTBs from the perspective of productivity shocks on domestic importers and exporters.

Importer and exporter efficiency can be considered two distinct technology, or productivity, shocks that can be considered akin to import and export augmented technical changes, and two ways to model iceberg costs. Since import efficiency has been a core part of the GTAP model since 2000, much more has been written over its relative strengths and weaknesses. Al Shamakhi *et al*. (2018) suggests the import efficiency is used to represent "efficiency-enhancing measures such as Customs automation or e-commerce that serve to reduce the effective price of goods and services imported" (p. 247). More exports will be required to meet the demand of the importing country (Fugazza and Maur, 2006). Extending this formulation to Brexit suggests that the process of leaving the EU Customs Union is an efficiency diminishing measure that increases the effective price of goods and services imported.

[3] We use this term when we refer to both database and model.

Table 4: Primary Mechanisms to Transmit Bilateral Trade Frictions (Tariffs and NTBs) in Walmsley and Strutt Bilateral Trade Model

Method	*Theoretical Formulation*	*Description*
Trade Taxes	$Q_{r,s} = Q_s \cdot \left[\frac{P_{r,s} \cdot [1 + T^M_{r,s}]}{P_s}\right]^{-\sigma}$	A tariff that is levied on the price of a bilateral import (or export), with associated government revenues and increase in government expenditure that will somewhat mitigate the effects.
Importer Efficiency	$\frac{Q_{r,s}}{\tau_{r,s}} = Q_s \cdot \left[\frac{P_{r,s} \cdot [1 + \tau_{r,s}]}{P_s}\right]^{-\sigma}$	Following Samuelson, this reduces the amount of goods arriving in a country. This formulation negatively impacts importers. The quantity arriving in the importing country is lower than what left the dock of the exporting country, i.e. the amount being imported is now $\left[\frac{Q_{r,s}}{\tau_{r,s}}\right]$ instead of $Q_{r,s}$.
Exporter Efficiency	$PE_{i,r,s} = \frac{PZ_{i,r}}{AXS_{i,r,s}} \cdot TO_{i,r}$	A workaround to apply the iceberg method to exports. Reducing NTBs under this formulation results in fewer inputs that are needed to export the initial amount.

Source: Model and accompanying specifications taken from Walmsley and Strutt (2018, 2021).

Note: Where $Q_{r,s}$ is the demand for goods from country r by country s; Q_s is the demand for imported goods by country s; P is the associated price; $[1 + T^M_{r,s}]$, TO refers to the tax rates, $AXS_{i,r,s}$ and $\tau_{r,s}$ refer to the respective NTB. $PE_{i,r,s}$is the new price of exports after application of $AXS_{i,r,s}$.

In the case of a hypothetical Brexit technical change, whether it be importer or exporter, these simulations would show various expected substitution effects that would occur in the real-world. So, if NI-GB importers (or exporters) become less efficient, there will be reduced demand from GB imports (exports) in NI. However, this will come with a much more explicit supply shift, whereby exporters need more GB inputs to produce the same level of outputs.

Exporter efficiency, on the other hand, is a relatively new addition to the suite of trade frictions captured in GTAP. For simplicity, and since GTAP does not distinguish between firms that export goods and those that supply to a domestic market, the change in exporter costs is weighted and applied on a sector-wide basis. The basis for creating the variable can be seen by the way in which importer efficiency traditionally applied the iceberg method to importers, and not exporters. In the context of Brexit, this would have suggested that importing countries would be principally affected from NTBs arising from Brexit rather than exporters.

The *a priori* view of the authors, then, would be that the choice of AXS or AMS matters primarily in the case of asymmetric shocks at an aggregate level, or in asymmetric trading relationships. The UK government has consistently maintained NI firms will continue to have "unfettered access" to GB (BBC, 2021) without offering the same guarantee for GB exporters. This might mean that the UK is planning for an *Asymmetric Access* scenario, and so the choice of shock variable would, then, be important. It should also be noted that it is unclear what is currently implemented since the UK has not implemented the NIP in full, and if *Asymmetric Access* is currently being observed in emerging trade data.

VI IDENTIFYING WINNERS AND LOSERS

Food manufacturing firms generally produce goods for export as opposed to primary agricultural sectors which produce goods for food manufacturing firms. The exception being crops, and particularly *Vegetables* and some *Other Crops* (such as mushrooms). While some cereal production takes place in NI and IRL, there are no cash crops, and none exported in relatively large quantities when compared to food manufacturing products. In other words, NI and IRL firms may compete against one another to some extent in terms of food manufacturing, but not directly in terms of agricultural primary goods.

Food manufacturing firms in IRL and NI all have associated domestic agricultural sectors. The performance of agricultural sectors will generally depend a great deal on the performance of their associated food manufacturing sector in the local area, albeit with subsidies distorting outcomes. This means that if NI *Dairy Products* expand production, ceteris paribus, NI *Raw Milk* production on farms should also expand production capacity proportionately.

Since there are a small number of scenarios in this study, with few anticipated outliers, the maximum absolute distance, or range of values, between output changes across scenarios, $\alpha_{i,r}$, where i is the sector and r is the region can be used to examine the extent of variability by sector to changes in the NIP. This means that if $\alpha_{i,r_1} > \alpha_{i,r_2}$, r_1 can be said to be more sensitive to the choice of NIP than r_2 for sector i. In other words, regions with higher range of estimates across the NIP scenarios are more sensitive to the NIP, and those with lower ranges are less sensitive. This, ultimately, describes how sensitive a sector is to the choice of NIP. More refined descriptives could be used, though the lack of scenarios (or stochastic modelling) prohibits this.

For any given NIP scenario, the NI result for a given sector will be the consequence of several different pressures. The exporter productivity shock, for example, will affect all regions in the model asymmetrically depending on their export intensities. Spillover effects will also be significant and UK-IRL trade disruption will occur simultaneously in NI alongside any disruption to NI external trade, and vice versa.

Collapsing regions clearly makes the problem simpler, though this often results in meaningless or trivial results. The RoW results have been removed since it is a vast region representing the global economy except most, but not all, of Europe. Equally, relatively small changes in EU output could indicate much larger impacts for individual Member States. An ISL figure, however, is useful for several reasons. The primary, and arguably only important reason, however, is that the results have some tangible real-world meaning since it is assumed that several NI and IRL agri-food sectors are integrated, and the ISL represents a single island economy albeit it with a land border. For better or worse, this assumption is at the heart of the NIP, and establishes ISL as something of a singular market for goods (which can be seen to be the source of contention in the UK).

However, the ISL figure clearly has analytical value as well, regardless of its real-world meaning. In the same way as taking an average of a country or countries to compare performance of the component regions, ISL can be used in conjunction with NI and IRL figures to surmise the extent to which NI or IRL benefit or lose out, perhaps at the expense of one another. It is entirely possible for ISL to be less sensitive to the NIP than either NI or IRL. An extreme example would be where ISL is completely unresponsive to the NIP, but IRL or NI are highly sensitive. This could happen if IRL or NI experience sharp contractions in output and the other region experiences correspondingly sharp expansions. In such a case, it would be sensible to conclude one region benefits at the other's expense.

VII ECONOMY-WIDE RESULTS

Tables 6 and 7 present results that show neither UK nor IRL are particularly sensitive to the nature of the NIP. While Brexit impacts are non-trivial, they do not vary with the choice of protocol. NI, on the other hand, is highly sensitive to the choice of NIP, as is to be expected, with a large variation in predicted GDP. The agreed NIP is probably not the best of the four options discussed. Though the unilateral implementation by the UK of the NIP probably means something close to *Asymmetric Access*, the UK position is that it conforms to *Best of Both Worlds*, likely the best outcome for the NI economy. While certain sectors may be affected, overall, the GB economy is predicted to be broadly unaffected by any shift from *NI in EU* to *Best of Both Worlds* or *Asymmetric Access*, where around 0.05 per cent of British GDP is at stake with low trade costs.

Best of Both Worlds implies problems associated with exporting and importing to and from NI are eliminated (Table 5). More likely, a form of *Asymmetric Access* is being implemented and unilaterally formalised by the UK, where importing from GB to NI is being made progressively more difficult. If there is *Asymmetric Access* to GB, there should be emerging costs associated with NI importing from GB (Table 6). Of the differences between Table 5 and 6, *Asymmetric Access* is, by far, the starkest.

Table 5: GDP Impact of EU Brexit and NIP Systems (Exporter Efficiency)

	NI in EU		*NI in UK*		*Best of Both Worlds*		*Asymmetric Access*	
	Low	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
Ireland	–0.32%	–0.96%	–0.34%	–1.08%	–0.32%	–0.97%	–0.32%	–0.97%
Northern Ireland	–0.36%	–1.61%	–0.29%	–0.98%	–0.17%	–0.14%	–0.22%	–0.53%
Island of Ireland	–0.33%	–1.12%	–0.33%	–1.05%	–0.29%	–0.77%	–0.30%	–0.86%
Great Britain	–0.35%	–1.10%	–0.35%	–1.04%	–0.35%	–1.04%	–0.35%	–1.10%
United Kingdom	–0.35%	–1.11%	–0.34%	–1.04%	–0.34%	–1.02%	–0.35%	–1.08%
EU	–0.05%	–0.20%	–0.05%	–0.21%	–0.05%	–0.20%	–0.05%	–0.20%
Rest of World	0.00%	0.01%	0.00%	0.01%	0.00%	0.01%	0.00%	0.01%

Source: GTAP model and GTAP 10 database (Aguiar *et al.*, 2010) with NI split, generated using coefficients from AFBI Input-Output table (see Greig and Wu, 2021) results from scenarios detailed in paper.
Note: Low refers to UK Government estimates of its NTBs imposed, High refers to UK Government modelled average from literature, as indicated in Table 3.

Table 6: GDP Impact of EU Brexit and NIP Systems (Importer Efficiency)

	NI in EU		*NI in UK*		*Best of Both Worlds*		*Asymmetric Access*	
	Low	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
Ireland	–0.46%	–1.42%	–0.47%	–1.55%	–0.46%	–1.42%	–0.46%	–1.43%
Northern Ireland	–0.36%	–2.20%	–0.19%	–0.78%	–0.08%	–0.02%	–0.36%	–2.15%
Island of Ireland	–0.43%	–1.61%	–0.40%	–1.36%	–0.37%	–1.08%	–0.43%	–1.60%
Great Britain	–0.33%	–1.31%	–0.33%	–1.27%	–0.33%	–1.27%	–0.33%	–1.28%
United Kingdom	–0.34%	–1.33%	–0.33%	–1.26%	–0.32%	–1.24%	–0.33%	–1.30%
EU	–0.05%	–0.16%	–0.05%	–0.16%	–0.05%	–0.16%	–0.05%	–0.16%
Rest of World	0.00%	0.01%	0.00%	0.01%	0.00%	0.01%	0.00%	0.01%

Source: GTAP model and GTAP 10 database (Aguiar *et al.*, 2010) with NI split, generated using coefficients from AFBI Input-Output table (see Greig and Wu, 2021) results from scenarios detailed in paper.

Barriers can potentially affect NI importers severely, particularly as exporters traditionally gain much attention in policymaking. While some observers see NI being given "preferential access" and perhaps even a competitive advantage over GB firms, it is plausible the opposite could happen if it becomes increasingly costly for NI firms to purchase inputs from long-established suppliers and – more generally – NI becomes an outlier and a place seen as difficult to do business. In other words, NI becoming a "special case" could have positive and negative dimensions, and *Asymmetric Access* implied by the NIP Bill merely cause different kinds of problems for NI.

A global CGE model that is rooted in textbook economic theory derives many results that should come as no surprise, NI tends to benefit in scenarios where there are fewer NTBs. Likewise, solutions to the NIP which reduce barriers disrupt all the economies less. Furthermore, the model suggests that the NIP, and whatever form it takes, is relatively unimportant economically for non-NI regions, when compared to the overall impact of Brexit. At a push, *Best of Both Worlds* scenarios – whereby NI retains unfettered access to both the EU and GB markets - can be painted as an outcome which tends to limit overall disruption in all regions modelled, albeit very marginally in the non-NI regions.

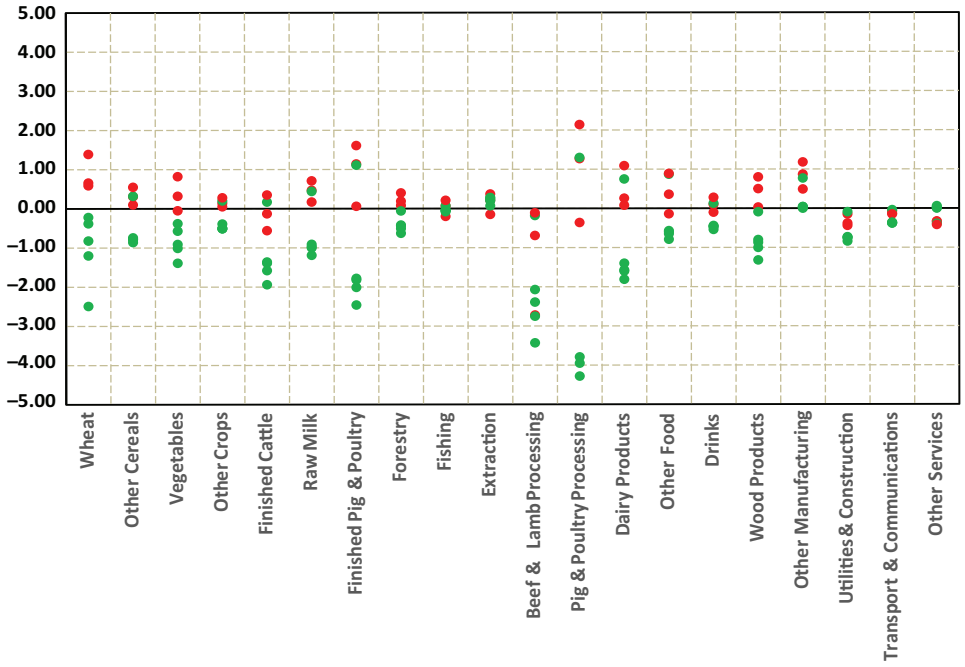
VIII IMPACT ACROSS AGRI-FOOD ECONOMY

Sectoral output impacts of different scenarios are outlined in Table 3 with respect to changes in export and import efficiencies are shown in Figures 1 and 2, respectively. These figures shows that several sectors, particularly in IRL, exhibit no variability in output to the form of the NIP (especially services). This will be primarily determined by exposure of the sector to the GB market and can be inferred from the variation across scenarios discussed at an aggregate level (i.e. GDP in Tables 6 and 7). The underlying data for Figure 1 are available in the Appendix.

IRL is a service-based economy, and while there is a slight negative impact of Brexit on the output of IRL service sectors, the form of NIP has little or no impact on these sectors (the form of the Brexit deal for services, obviously being much more important). In the case of services, the range α only varies between 0.01 and 0.11 percentage points across the three IRL services, as illustrated in both figures.

The "low" scenarios should be given more substance since it is likely that something closer to *low* NTBs have been introduced between the UK and EU and so resemble the TCA and the agreed, but not implemented, NIP. The *NI in EU* tended to be the one of the worst-case scenarios for NI agri-food sectors, as implied in Tables 6 and 7, but one of the best for IRL agri-food sectors. Though, for NI food manufacturers, only the beef supply chain suffers a contraction in all low scenarios. Speculatively, this may be due to the GB-EU trade frictions limiting GB exports of beef and lamb products to EU markets, putting demand pressure on NI beef and lamb exports to GB.

Figure 1: Variation in Output Across NI Protocol Scenarios (Exporter Efficiency) for the NI (Red) and IRL (Green) Economies, by Sector (UK Government, or "Low", Expectations)



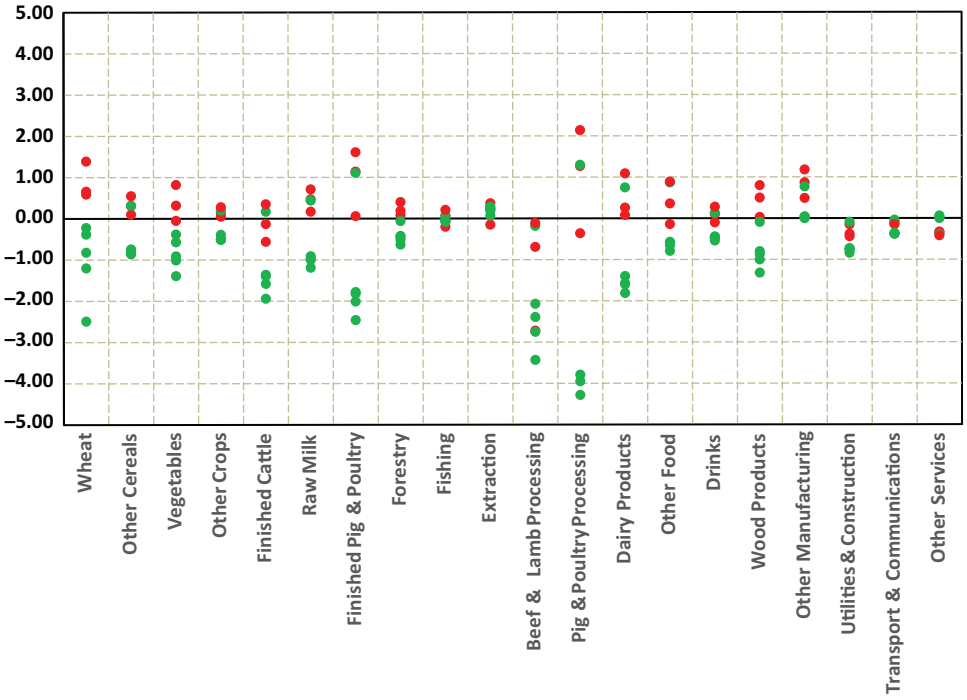
Source: GTAP model and GTAP 10 database (Aguiar *et al.*, 2010) with NI split, generated using coefficients from AFBI Input-Output table (see Greig and Wu, 2021) results from scenarios detailed in paper.

So, *Beef & Lamb manufacturing* is particularly exposed to Brexit and highly sensitive to the form of the NIP. Otherwise, NI agri-food exports appear resilient to the choice of NIP, and Brexit, with opportunities to expand. IRL food manufacturing, on the other hand, may need to manage sectoral decline from Brexit, and the scale of that decline is sensitive to the choice of NIP; *Pig & Poultry* in particular stands out. This sector may benefit from further disaggregation, though, if either *Pig* or *Poultry* is much more exposed than the other, that sector will face exceptionally significant challenges.

It follows that the associated agricultural sectors tend to follow the performance of its manufacturing sector. If *NI Dairy* witnesses an expansion, there is increased demand for *NI Raw Milk*, and so on. The input structures assumed for NI agricultural sectors likely cushion these sectors from more serious declines (NI *Finished Cattle & Lamb* being the most obvious case). This is assumed to be the impact of subsidy payments as well as the fact that agri-food manufacturing bears the direct impact of increased trade costs.

The sectors most sensitive to the choice of NIP is *Wheat* ($\alpha_{Wheat,\ NI} = 2.21/\alpha_{Wheat,\ IRL} = 2.27$, *Beef & Lamb* ($\alpha_{Beefmeat,\ NI} = 2.61/\alpha_{Beefmeat,\ IRL} = 1.36$), and

Figure 2: Variation in Output Across NI Protocol Scenarios (Importer Efficiency) for the NI (Red) and IRL (Green) Economies, by Sector (UK Government, or "Low", Expectations)



Source: GTAP model and GTAP 10 database (Aguiar *et al.*, 2010) with NI split, generated using coefficients from AFBI Input-Output table (see Greig and Wu, 2021) results from scenarios detailed in paper.

Pig & Poultry ($\alpha_{Pig\&Poultry,\ NI} = 2.50/\sigma_{Pig\&Poultry,\ IRL} = 1.36$), compared to very little sensitivity at an economy-wide level shown in Table 5 (e.g. $\alpha_{ALL,\ NI} = 0.26$). An important feature of the results is that importer and exporter efficiency only appear to affect the scale of impacts. This is true for exporter and importer efficiency and for NI and IRL and can be seen from Figures 1 and 2. Importer efficiency is no longer reported, due to this similarity in results.

It follows that all NI sectors are more sensitive to the form of the NIP than IRL, and IRL sectors are more sensitive than GB ones ($\alpha_{i,NI} > \alpha_{i,IRL} > \alpha_{i,GB}$ for all i). This general observation holds for both importer and exporter efficiency mechanisms across all sectors, for the UK Government's anticipated Brexit (or "Low" expectations).

IX ISLAND OF IRELAND RESULTS

Table 7 shows the results for the combined NI and IRL impacts on output by sector, i.e. the ISL impacts. Similar tables for NI and IRL are included in the Appendix.

Table 7: Output Changes for the Island of Ireland (ISL) Arising from Brexit, by Sector Across All Northern Ireland Protocol Scenarios, Export Efficiency

	NI in EU		*NI in UK*		*Best of Both Worlds*		*Assymetric Access*	
	Low	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
Wheat	–0.03%	3.37%	–0.03%	–10.00%	–1.13%	–5.74%	–0.06%	3.44%
Other Cereals	–0.66%	–5.36%	–0.66%	–4.15%	–0.68%	–5.49%	–0.64%	–5.12%
Vegetables	–0.74%	–6.91%	–0.74%	–5.48%	–0.84%	–7.73%	–0.44%	–4.44%
Other Crops	–0.33%	–2.29%	–0.33%	–2.80%	–0.41%	–2.92%	–0.39%	–2.73%
Finished Cattle	–1.13%	–6.91%	–1.13%	–8.18%	–1.08%	–6.39%	–0.89%	–4.83%
Raw Milk	–0.49%	–3.64%	–0.49%	–5.72%	–0.56%	–4.13%	–0.45%	–3.20%
Finished Pig & Poultry	–0.88%	–7.18%	–0.88%	–4.27%	–0.48%	–3.69%	–0.14%	–0.69%
Forestry	–0.35%	–1.43%	–0.35%	–2.54%	–0.45%	–2.30%	–0.30%	–1.04%
Fishing	–0.06%	–0.68%	–0.06%	–0.14%	–0.03%	–0.37%	0.01%	–0.10%
Extraction	0.25%	1.24%	0.25%	0.38%	0.17%	0.28%	0.32%	1.53%
Beef & Lamb Manufacturing	–2.30%	–14.12%	–2.30%	–13.04%	–1.81%	–10.34%	–1.56%	–8.21%
Pig & Poultry Manufacturing	–2.27%	–14.75%	–2.27%	–11.11%	–1.81%	–10.62%	–1.25%	–5.84%
Dairy Products	–0.90%	–6.78%	–0.90%	–7.13%	–0.88%	–6.58%	–0.76%	–5.56%
Other Food	–0.46%	–4.64%	–0.46%	–2.91%	–0.23%	–2.77%	–0.20%	–2.47%
Drinks	–0.24%	–1.72%	–0.24%	0.17%	–0.12%	–0.64%	–0.02%	0.14%
Wood Products	–0.41%	0.36%	–0.41%	–2.18%	–0.69%	–2.02%	–0.26%	1.62%
Other Manufacturing	0.20%	0.39%	0.20%	0.41%	0.16%	0.09%	0.25%	0.81%
Utilities & Construction	–0.59%	–3.35%	–0.59%	–2.99%	–0.49%	–2.54%	–0.62%	–3.57%
Transport & Communications	–0.32%	–0.61%	–0.32%	–0.17%	–0.29%	–0.38%	–0.32%	–0.64%
Other Services	–0.07%	0.28%	–0.07%	0.80%	–0.07%	0.31%	–0.09%	0.14%

Source: GTAP model and GTAP 10 database (Aguiar *et al.*, 2010) with NI split, generated using coefficients from AFBI Input-Output table (see Greig and Wu, 2021) results from scenarios detailed in paper.

Every agri-food component on ISL faces downward demand pressures due to barriers in the Irish Sea, though this is due to the disproportionately large falls in output for IRL agri-food sectors.

An important point here is that the agreed NIP tends to be one of the worst performers for ISL, but one of the better solutions for IRL. The *Best of Both Worlds* scenario could put pressure on ISL (or IRL) *Beef & Lamb* and *Pig & Poultry*. The best performer is *Asymmetric Access* (exporter) for these sectors, this is because NI is assumed to receive preferential access to the GB market with no cost, and successfully offsets the large decline in IRL agri-food. How realistic this scenario is in practice is, however, guesswork. Overall, the results tend to show ISL agri-food sectors are hurt most by the *NI in UK* scenarios, and this can be attributed to larger falls in IRL that are not compensated through increased NI-GB trade. This strongly suggests that while it is true NI agri-food firms might benefit from a reduction in IRL-GB trade, it is unlikely all IRL trade will be diverted in this way. Output from NI *Beef & Lamb Manufacturing*, for example, is still predicted to fall in this scenario, though it is the only NI food manufacturing sector to experience such a decline.

Table 8: Absolute Range of Estimates by Sector, for NI, IRL and ISL, Percentage Point, Export Efficiency

	Northern Ireland		*Rest of Ireland*		*All-Ireland*	
	Low	*High*	*Low*	*High*	*Low*	*High*
Wheat	2.21%	17.68%	2.27%	18.42%	1.10%	13.44%
Other Cereals	0.45%	3.76%	0.12%	1.01%	0.04%	1.34%
Vegetables	1.20%	9.79%	0.82%	6.76%	0.39%	3.29%
Other Crops	0.23%	1.97%	0.12%	1.10%	0.08%	0.63%
Finished Cattle	0.91%	7.00%	0.58%	4.28%	0.24%	3.35%
Raw Milk	0.54%	3.82%	0.28%	2.22%	0.11%	2.53%
Finished Pig & Poultry	1.55%	13.26%	0.68%	5.11%	0.74%	6.48%
Forestry	0.46%	3.75%	0.21%	1.75%	0.15%	1.50%
Fishing	0.41%	3.37%	0.04%	0.35%	0.07%	0.58%
Extraction	0.52%	4.07%	0.08%	0.52%	0.15%	1.25%
Beef & Lamb Processing	2.61%	18.91%	1.36%	9.28%	0.75%	5.91%
Pig & Poultry Processing	2.50%	20.95%	1.35%	9.10%	1.02%	8.90%
Dairy Products	1.01%	7.03%	0.41%	3.29%	0.13%	1.57%
Other Food	1.03%	8.53%	0.22%	1.71%	0.26%	2.17%
Drinks	0.38%	3.24%	0.10%	0.81%	0.21%	1.90%
Wood Products	0.89%	7.47%	0.52%	3.96%	0.43%	3.81%
Other Manufacturing	0.69%	5.18%	0.04%	0.31%	0.09%	0.72%
Utilities & Construction	0.35%	2.84%	0.11%	0.84%	0.13%	1.04%
Transport & Communications	0.11%	0.83%	0.02%	0.12%	0.03%	0.47%
Other Services	0.09%	0.73%	0.06%	0.40%	0.02%	0.66%

Source: GTAP model and GTAP 10 database (Aguiar *et al.*, 2010) with NI split, generated using coefficients from AFBI Input-Output table (see Greig and Wu, 2021) results from scenarios detailed in paper.

The overall results, however, suggest the potential for strong declines in ISL food manufacturing output and these losses will be materially affected by the choice of NIP. NI *Dairy Products* and its associated *Raw Milk* sector seem the most robust to changes in NIP, with potential expansion in all iterations. This will be, in part, due to the ISL dairy market being more integrated than other agri-food sectors (i.e. NI has more diversified export destinations and so less exposure to Brexit generally). Though the agreed NIP (*NI in EU*) is one of the more modest increases, the result for ISL is still a net fall in *Dairy* and *Raw Milk* output driven by falls in output of IRL *Dairy Products* and *Raw Milk*.

Table 8 shows that all sectors in ISL, $\alpha_{i,ISL}$ are less variable than for either NI or IRL (except *Wheat*, where the ISL figure is more variable than NI's *Wheat* sector). Taken with Figure 1 and 2, and Table 7, the lower ISL range is a result of NI and IRL having generally negatively correlating sectoral performance across NIP scenarios (a "better" NIP for NI agri-food will result in a worse deal for IRL agri-food, and vice-versa) and this results in a net loss in output for the ISL sector (enhanced NI goods access to GB can, at best, barely compensate the decline arising from GB-IRL frictions).

X DISCUSSION

The role policymakers can have in economic planning is greatly complicated by the fact that the NIP has not been implemented quickly, and there are legitimate questions about whether the NIP will ever be set in stone. The evidence here suggests this is clearly a much bigger issue for NI than those negotiating (or implementing) the NIP. Indeed, the economies of IRL and GB are barely affected by the choice of NIP, and while IRL agri-food is sensitive to the NIP, and that may be politically awkward, these appear to have very muted aggregate effects on the IRL economy.

The evidence does suggest, overall, ISL agri-food sectors are less sensitive to changes in the NIP than its constituent parts. This paper shows that this occurs due to considerable offsetting that can be attributed to IRL-NI trade diversion. Though it is not entirely correct to see the NIP purely in terms of potential trade diversion from IRL-GB to NI-GB, this is will undoubtedly be occurring in terms of food manufacturing exports across all sectors. The ISL figures show that no solution will offset the projected decline in IRL agri-food, and trade may be diverted somewhere else entirely.

If the UK NIP Bill is brought forward and the basis for further negotiation, there may be some reprieve for NI agri-food. Some form of *Asymmetric Access*, whereby NI exporters are given preferential access to the UK and unfettered access to the EU, could offset some of reported ISL decline, though it is not unreasonable to suppose that such an arrangement might simply penalise NI importers instead of

GB exporters. This paper has tested a mechanism of how that might occur and shown that those assumptions could be as serious as a hard border (if NI importers bear the brunt instead of GB exporters).

In terms of policy suggestions, there are several blithe suggestions that are correct but would be impossible for NI policymakers to implement, such as "work together toward a stable Brexit deal". However, assuming the NIP, over time, does not introduce significant barriers to NI exporting firms, and the focus of the NIP Bill is to assist NI exporters, there may be future opportunity for NI agri-food firms to expand much more explicitly into IRL food manufacturing, with careful implementation of rules relating to bilateral cumulation for entry into GB. This would go beyond distribution activities and viewing NI more than a potential transhipment hub, and closer to a manufacturing one. Curiously, these types of policies may become more attractive for NI (and possibly IRL farmers) with closer NI-GB (as opposed to NI-EU) regulatory alignment, and there would be the economically interesting scenario of NI-IRL regulatory divergence, but with increased agri-food integration.

Arguably most conventional CGE modelling approaches, which tend to rely on Armington specifications of import demand, will be sensitive to existing bilateral trade patterns. Namely, small shares of bilateral imports and/or exports will stay small. If there are significant IRL-GB or NI-GB barriers, it is unclear how accurately this framework will introduce completely new trading relationships on a sector-by-sector basis, which are not already defined in the data. These issues can overestimate the negative impacts of bilateral trade disruption.

This will apply to IRL-NI importing as well as exporting. It is true that NI could look for exciting new export destinations that might be out of reach of other UK agri-food manufacturers. However, if there is the potential for trade diversion from IRL to NI, this may provide scope for increased NI primary good importing from IRL, which – for many agricultural sectors – will start from a low base in the GTAP database. Ultimately, NI should be aware of not just the costs exporters may face in dual-regulatory regimes or being part of the EU common market for agri-food, but the potential for importing opportunities.

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APPENDIX

Table A.1: Change in Output from Exporter Efficiency Shocks, Northern Ireland Results by Sector

	NI in EU		*NI in UK*		*Best of Both Worlds*		*Assymetric Access*	
	Low	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
Wheat	1.39%	12.16%	0.66%	4.54%	–0.82%	–5.52%	0.59%	5.48%
Other Cereals	0.10%	0.56%	0.31%	2.53%	0.32%	2.45%	0.55%	4.32%
Vegetables	0.82%	6.60%	–0.05%	–1.07%	–0.38%	–3.19%	0.32%	2.37%
Other Crops	0.05%	0.24%	0.14%	1.17%	0.20%	1.58%	0.28%	2.21%
Finished Cattle & Lamb	–0.56%	–3.63%	–0.13%	–0.37%	0.17%	1.94%	0.35%	3.37%
Raw Milk	0.47%	3.26%	0.17%	1.72%	0.44%	3.32%	0.71%	5.54%
Finished Pig & Poultry	0.06%	–0.96%	1.14%	8.82%	1.11%	7.97%	1.61%	12.30%
Forestry	0.19%	1.93%	0.08%	0.63%	–0.06%	–0.26%	0.40%	3.49%
Fishing	–0.20%	–1.93%	0.07%	0.27%	0.07%	0.33%	0.21%	1.44%
Extraction	0.21%	1.33%	–0.15%	–2.13%	0.07%	–0.52%	0.37%	1.94%
Beef & Lamb Manufacturing	–2.72%	–18.80%	–0.69%	–4.08%	–0.18%	–0.42%	–0.11%	0.11%
Pig & Poultry Manufacturing	–0.36%	–3.99%	1.27%	10.33%	1.30%	9.70%	2.14%	16.96%
Dairy Products	0.26%	1.64%	0.08%	1.64%	0.75%	5.94%	1.09%	8.67%
Other Food	–0.14%	–1.95%	0.36%	2.70%	0.87%	6.48%	0.89%	6.58%
Drinks	–0.10%	–0.97%	0.10%	0.55%	0.13%	1.03%	0.28%	2.27%
Wood Products	0.50%	5.59%	0.03%	1.02%	–0.09%	0.61%	0.80%	8.08%
Other Manufacturing	0.87%	3.79%	0.49%	0.94%	0.77%	2.81%	1.18%	6.12%
Utilities & Construction	–0.38%	–3.10%	–0.15%	–1.09%	–0.09%	–0.68%	–0.44%	–3.52%
Transport & Communications	–0.13%	–0.73%	–0.07%	–0.20%	–0.04%	0.01%	–0.15%	–0.82%
Other Services	–0.33%	–0.65%	–0.34%	–0.77%	–0.39%	–1.11%	–0.42%	–1.38%

Source: GTAP model and GTAP 10 database (Aguiar *et al.*, 2010) with NI split, generated using coefficients from AFBI Input-Output table (see Greig and Wu, 2021) results from scenarios detailed in paper.
Note: Importer efficiency excluded for concision, results remain qualitatively similar. Results show change in total output by sector.

Table A.2: Sectoral Change in Output from Exporter Efficiency Shocks, Republic of Ireland Results by Sector

	NI in EU		*NI in UK*		*Best of Both Worlds*		*Assymetric Access*	
	Low	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
Wheat	–0.38%	1.19%	–2.49%	–15.49%	–1.20%	–5.79%	–0.22%	2.93%
Other Cereals	–0.74%	–6.01%	–0.86%	–7.02%	–0.79%	–6.36%	–0.77%	–6.16%
Vegetables	–1.01%	–9.23%	–1.39%	–12.37%	–0.91%	–8.52%	–0.57%	–5.61%
Other Crops	–0.39%	–2.69%	–0.51%	–3.79%	–0.51%	–3.63%	–0.50%	–3.51%
Finished Cattle & Lamb	–1.36%	–8.23%	–1.94%	–12.40%	–1.58%	–9.75%	–1.39%	–8.12%
Raw Milk	–0.91%	–6.73%	–1.19%	–8.95%	–1.00%	–7.46%	–0.97%	–7.11%
Finished Pig & Poultry	–1.78%	–13.17%	–2.46%	–18.28%	–2.01%	–14.93%	–1.82%	–13.22%
Forestry	–0.44%	–2.00%	–0.63%	–3.55%	–0.51%	–2.64%	–0.42%	–1.80%
Fishing	–0.04%	–0.42%	–0.08%	–0.77%	–0.05%	–0.51%	–0.04%	–0.42%
Extraction	0.27%	1.17%	0.20%	0.73%	0.23%	0.80%	0.28%	1.25%
Beef & Lamb Manufacturing	–2.07%	–11.43%	–3.43%	–20.71%	–2.75%	–16.06%	–2.39%	–13.00%
Pig & Poultry Manufacturing	–3.79%	–23.29%	–5.14%	–32.39%	–4.28%	–26.77%	–3.95%	–23.97%
Dairy Products	–1.40%	–10.45%	–1.81%	–13.74%	–1.60%	–12.03%	–1.57%	–11.76%
Other Food	–0.57%	–5.65%	–0.79%	–7.36%	–0.65%	–6.23%	–0.60%	–5.86%
Drinks	–0.44%	–2.82%	–0.54%	–3.63%	–0.47%	–3.09%	–0.46%	–2.99%
Wood Products	–0.87%	–2.28%	–1.32%	–5.61%	–1.00%	–3.36%	–0.80%	–1.65%
Other Manufacturing	0.04%	–0.39%	0.00%	–0.70%	0.02%	–0.54%	0.04%	–0.41%
Utilities & Construction	–0.73%	–3.51%	–0.84%	–4.35%	–0.76%	–3.78%	–0.74%	–3.61%
Transport & Communications	–0.38%	–0.57%	–0.36%	–0.47%	–0.37%	–0.51%	–0.38%	–0.59%
Other Services	0.00%	0.54%	0.06%	0.94%	0.03%	0.71%	0.01%	0.56%

Source: GTAP model and GTAP 10 database (Aguiar *et al.*, 2010) with NI split, generated using coefficients from AFBI Input-Output table (see Greig and Wu, 2021) results from scenarios detailed in paper.
Note: Importer efficiency excluded for concision, results remain qualitatively similar. Results show change in total output by sector.