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The Impact of Fit for 55 on Ireland's Maritime Transport Sector and the Macroeconomy

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Executive Summary

- The EU Green Deal aims to reduce greenhouse gas emissions by 55% across the EU by 2030 as an intermediate step towards a carbon-neutral economy by 2050. To support these efforts, the 'Fit for 55 package' is a set of proposals to revise EU laws and introduce new initiatives across a range of sectors aimed at ensuring that EU policies are consistent with these ambitious climate goals.

- In the maritime transport sector, the package includes a suite of new regulations and taxation measures to incentivise the use of Renewable and Low Carbon Fuels (RLFs). As the cost of RLFs is higher than traditional fossil fuels, ports, shipping operators and consumers of maritime transport services may face higher costs because of the transition to RLFs.

- In this study, we use a Vector Autoregressive model (VAR) to estimate the impact of the Fit for 55 package on Ireland's maritime transport sector and the broader Irish economy. We also provide an overview of the Irish maritime transport sector, outlining the structure of the sector, Ireland's main shipping partners, and the links between the sector and the Irish economy.

- The maritime transport sector generates about €1.6 billion in revenues and €450 million in Gross Value Added and employs nearly 5,000 people. The sector expanded strongly during most of the last decade, but experienced significant disruptions in recent years due to Brexit, the Covid-19 pandemic and subsequent shocks to global supply chains.

- Most of Irish port throughput is handled by the country's five largest commercial ports: Dublin, Cork, Shannon Foynes, Rosslare and Waterford. Cork, Dublin and Shannon Foynes are Ireland's largest ports by throughput volume and collectively handled around 91% of Irish port throughput over the period 1998–2021.

- 40% of Irish port tonnage was shipped between Ireland and the UK over the period 1998–2021, making the UK Ireland's most important shipping partner by a significant margin. The Netherlands was Ireland's second most important shipping partner,

accounting for 13% of the gross tonnage shipped to and from Irish ports, while Belgium accounted for 5%.

- The EU's Alternative Fuel Infrastructure (AFI) directive mandates that onshore power supply (OPS) must be made available for most ships at EU ports by 2030. The provision of OPS at Irish ports will carry capital and operating costs that must be bore by ports and ship operators. We estimate a capital cost of roughly between €28 million and €41 million and an annual operating cost of between €100,000 and €146,000 for Dublin port, and between €1.2 and €4.2 million for capital and between €4,300 and €15,000 for operational costs for Cork, Shannon Foynes, Rosslare and Waterford.

- The Fit for 55 package is projected to increase the price of maritime fuel by 28% by 2050 compared with a scenario where the sector continues to rely exclusively on liquid fossil fuels. Our analysis finds that, based on estimated historical relationships, a shock to the cost of maritime fuel of this magnitude is expected to reduce Gross Value Added (GVA) in the maritime transport sector by about 7.5% by 2050, relative to a "no-policy-change" baseline in which only liquid fossil fuels are used in the maritime fuel mix over the coming decades.

- We find that the incremental increase in the share of RLFs in the fuel mix over the next 25-30 years will gradually increase the magnitude of the effect on GVA, with the impact doubling between 2030 and 2035, increasing by almost 2% between 2035 and 2040, and increasing by just over 3% between 2040 and 2045.

- Turning to the broader Irish economy, our results indicate that switching to RLFs in the maritime sector will not have a material impact on overall economic activity.[1] The negative impact on real output, relative to baseline, is projected to range from 0.09% in 2025 to 1.21% in 2050. The projected decline in real exports ranges from 0.17% in 2025 to 2.29% in 2050. We find no statistically significant relationship between real imports and shocks to fuel prices. The Fit for 55 package is expected to result in a small increase in the general level of consumer prices in Ireland, with the impact ranging from 0.12% in 2025 to 1.83% in 2050.

[1] This analysis examines the impact of higher fuel costs only and does not account for the potential price impact of increased capital costs arising from the need to purchase and retrofit vessels to support renewable fuels.

1. Introduction

The EU Green Deal aims to reduce greenhouse gas (GHG) emissions by 55% across the EU by 2030 as an intermediate step towards a carbon-neutral economy by 2050. To support these efforts, the 'Fit for 55 package' is a set of proposals to revise EU laws and introduce new initiatives across a range of sectors aimed at ensuring that EU policies are consistent with these ambitious climate goals. In the maritime transport sector, the package includes a suite of new regulations and taxes to incentivise the use of Renewable and Low Carbon Fuels (RLFs). The use of RLFs will benefit societies by reducing the negative externalities associated with carbon emissions. However, the cost of RLFs is higher than traditional fossil fuels, and RLF markets and technology are still in the early stages of development. Ports, shipping operators and consumers of maritime transport services may face higher costs because of the transition to RLFs. Given the importance of maritime transport in facilitating EU trade, cost increases in the maritime transport sector could have broader macroeconomic effects, with pass-through to shipping prices potentially affecting aggregate demand, inflation, employment, trade and output.

Ireland as a small open economy and island nation is heavily dependent on international trade and is particularly exposed to increases in maritime transportation costs. Recent estimates show that the Irish maritime transport sector is responsible for handling up to 90% of the total volume and 56% of the total value of Irish trade cargoes (Fallen Bailey and Treacy, 2021; SEMRU, 2019). Output and employment in the Irish maritime transport sector and national port tonnage volumes reflect the close relationship between the sector and the broader economy, and have moved closely with Irish macroeconomic conditions in recent decades. Many studies have found that transportation costs are a significant determinant of trade flows (for example, Anderson and Van Wincoop, 2004; Behar and Venables, 2011; Bernard et al., 2018; Nanovsky, 2019; Beverelli et al., 2010). As fuel costs are a major component of transportation costs, the changes introduced by the Fit for 55 package could have a substantial effect on Ireland's trade flows, the Irish maritime transport sector and the broader Irish economy.

In this study, we use a Vector Autoregressive model (VAR) to estimate the impact of Fit for 55 on Ireland's maritime transport sector and the broader Irish economy. We first estimate the historical impact of changes in marine fuel prices on output, gross value added (GVA) and employment in the Irish maritime transport sector, as well as on aggregate output, trade, consumption, CPI and employment over the period 1995–2020. We then use our estimates of these historical relationships to project the effect of higher marine fuel prices on these variables from 2025–2050.

This report is organised in the following way. Section 2 provides an overview of the Irish maritime transport sector, outlining the structure of the sector, Ireland's main shipping partners, and the links between the sector and the broader Irish economy. Section 3 describes the directives of the Fit for 55 package, which mandate the future shares of RLFs in the maritime fuel mix from 2025 and a range of future taxation measures that aim to disincentivise the use of liquid fossil fuels. Section 4 outlines our empirical approach and VAR model. Section 5 presents and describes the data used in this study. Section 6 presents and discusses our results and projections. This section is divided into two subsections. The first provides cost estimates for the provision of onshore power supply (OPS) at Irish ports as mandated by the Fit for 55 package, and estimates and forecasts of the impact of fuel price increases on the Irish maritime transport sector. The second presents these estimates and forecasts for the broader Irish economy. Section 7 presents conclusions and discussions.

2. The Irish maritime transport sector

In this section, we provide an overview of the Irish maritime transport sector, detailing the linkages between the sector and the broader Irish economy, as well as trends in activity and employment in the sector, Irish trade and port throughput. In addition, as distance plays a large role in determining total fuel costs, we present details of Ireland's main shipping partners both at national and port level.

As a small open economy and island nation, maritime transport is crucial for the facilitation of Ireland’s external trade. The Irish maritime transport sector is comprised of a network of coastal ports and shipping operators that are responsible for the transport of passengers and goods to and from the island of Ireland. Historically, strong dependence on maritime transport for trade purposes has led to a significant correlation between the performance of the Irish maritime transport sector and the broader Irish economy, with sectoral output and employment trends closely mirroring trends in external trade and national output. Irish port throughput has increased by almost one third since 1998, but growth has been uneven and strongly influenced by macroeconomic conditions. Strong growth in the maritime transport sector during the Celtic Tiger years was followed by a sharp decline in the years following the 2008 Global Financial Crisis (GFC). Growth resumed from 2010, although pre-crisis peak levels of national throughput were not matched until 2018. Recently, significant disruptions to trade stemming from Brexit and especially the Covid-19 pandemic have resulted in a sharp dip in activity.

Figures 1-3 show the estimated value of direct turnover, gross value added (GVA) and employment in Ireland’s maritime transport sector over the past decade. These data are taken from various editions of the *Ireland’s Ocean Economy* report published by the Socio-Economic Marine Research Unit (SEMRU) at the University of Galway. They cover waterborne transport activities, including both freight and passenger transport, as well as many related services, including, *inter alia*, ship chartering and brokering, equipment leasing, and stevedoring.[2]

[2] These activities are captured by NACE industry codes: 50.10, 50.20, 52.22, 52.24, 52.29, and 77.34.

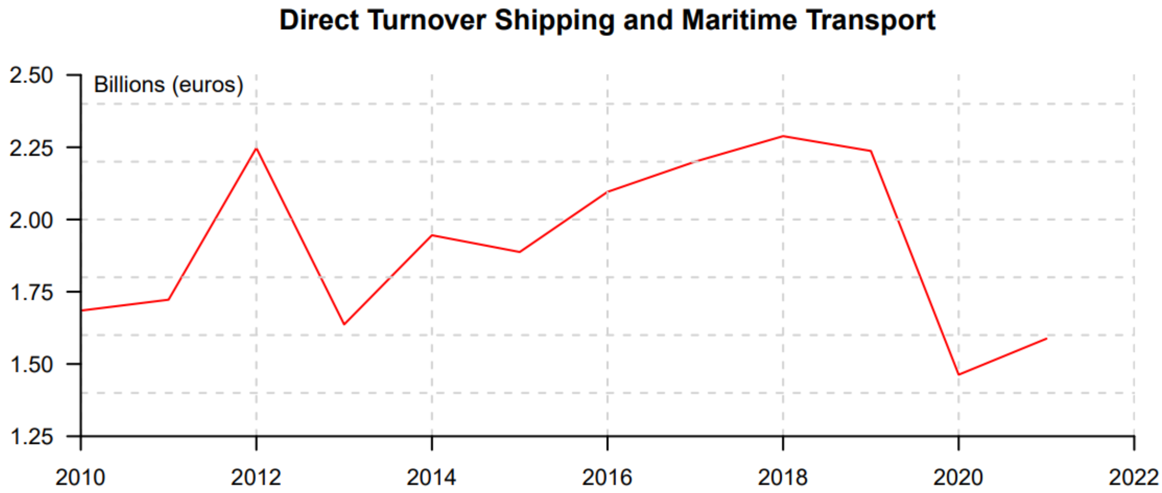

Figure 1: Irish Maritime Transport, Turnover (€ billions), 2010–2021

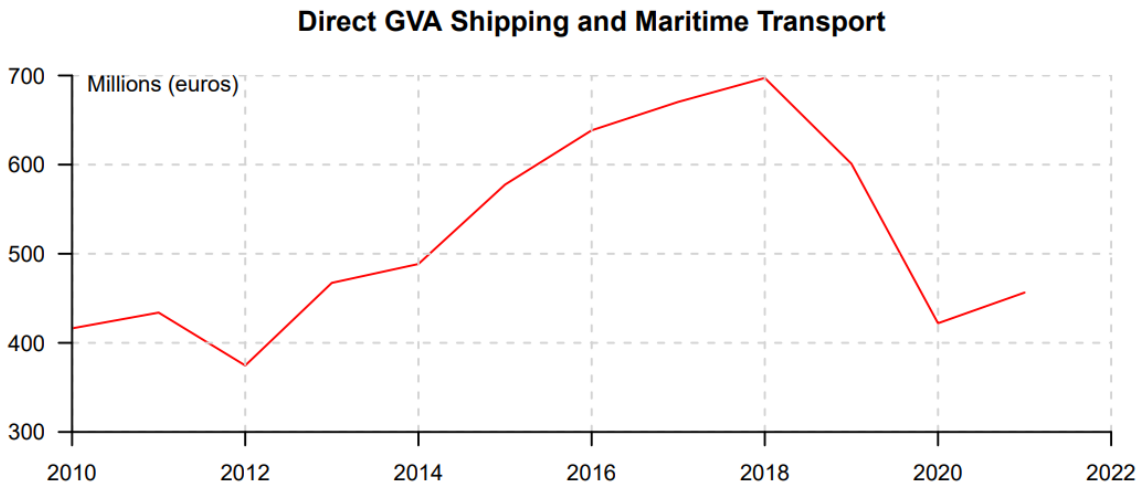

Figure 2: Irish Maritime Sector, GVA (€ millions), 2010–2021

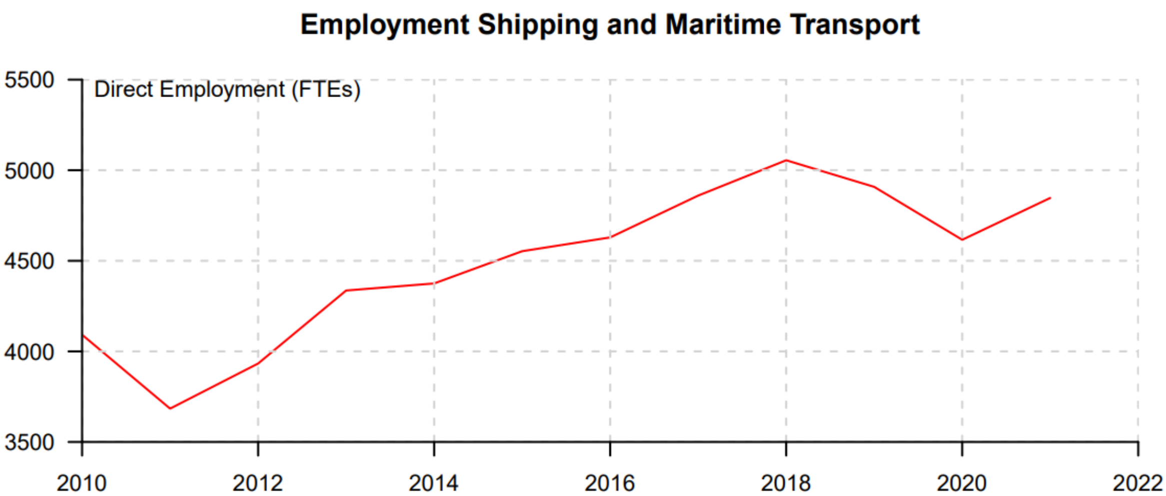

Figure 3: Irish Maritime Sector, Employment (FTEs), 2010–2021

In 2021, the latest year for which data are available, direct turnover in the sector was around €1.6 billion. That year, the sector generated about €450 million in value added and employed nearly 5,000 people. These figures refer only to the direct activity in the sector. SEMRU estimate that the indirect activity and employment generated by the sector is roughly of similar size as the direct measures.

As can be seen in Figures 1-3, activity and employment in the sector started to recover in 2012/13 as the Irish economy and wider European economy began to emerge from the euro area debt crisis. Over the period 2013-2018, turnover, GVA and employment expanded at a strong pace, increasing on average by 8%, 10% and 3.3%, respectively, per annum over the period. The softening in activity in 2019 reflected weakness in the dry bulk market due to the unwinding of excess inventories built up during the previous year. The years 2020 and 2021 saw significant constraints in terms of container shortages, lockdowninduced labour supply issues and general disruptions in supply chains as a result of the Pandemic.

Irish Trade and Port Throughput

Port throughput offers another lens through which to view activity in the maritime transport sector. Recent estimates suggest that there is a particularly strong correlation between Irish trade statistics and Irish port throughput, which as an island nation, reflects Ireland's strong dependence on maritime transport (SEMRU, 2019). The strength of this relationship is evident in Figure 4, which shows that port throughput has moved closely with Irish trade flows over recent decades. National port throughput increased consistently until the Global Financial Crisis (GFC) in 2008/9, reflecting strong national economic growth and an expansion of trade during the Celtic Tiger years. National throughput declined during the GFC and remained relatively static until 2012, when growth resumed. Although throughput grew at a solid pace over the last decade, national throughput did not return to pre-crisis peak levels until 2018. A national fodder crisis led to a temporary expansion of throughput in 2017 and 2018, and was followed by a sharp correction and subsequent decline in 2019 (Fallen Bailey and Treacy, 2021). The Covid-19 pandemic depressed throughput in 2020, and despite the post-Covid recovery, growth is again uncertain due to the global impact of the Russian war in Ukraine.

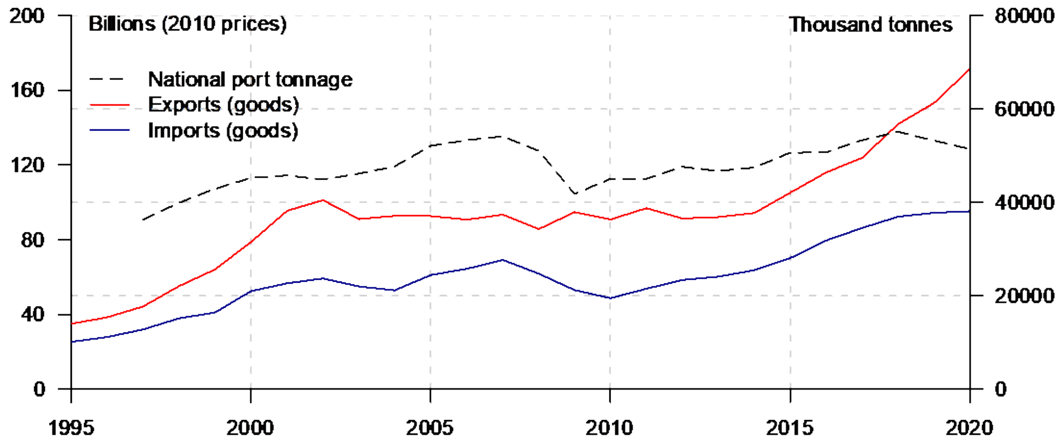

Figure 4: Irish national port throughput and trade 1995–2020

Most of Ireland’s port throughput is handled by the country’s five largest commercial ports: Dublin, Cork, Shannon Foynes, Rosslare and Waterford. Cork, Dublin and Shannon Foynes are Ireland's largest ports by throughput volume and collectively handled around 91% of Irish port throughput between 1998–2021. Over this period, Dublin handled the largest share of Irish port tonnage, shipping around 46% of Irish trade cargoes, while Shannon Foynes and Cork shipped around 24% and 21%, respectively. The ports of Rosslare and Waterford, both located in the south east of the country, are also ports of national significance, and each handled around 3% of national port tonnage over the period 1998–2021.[3]

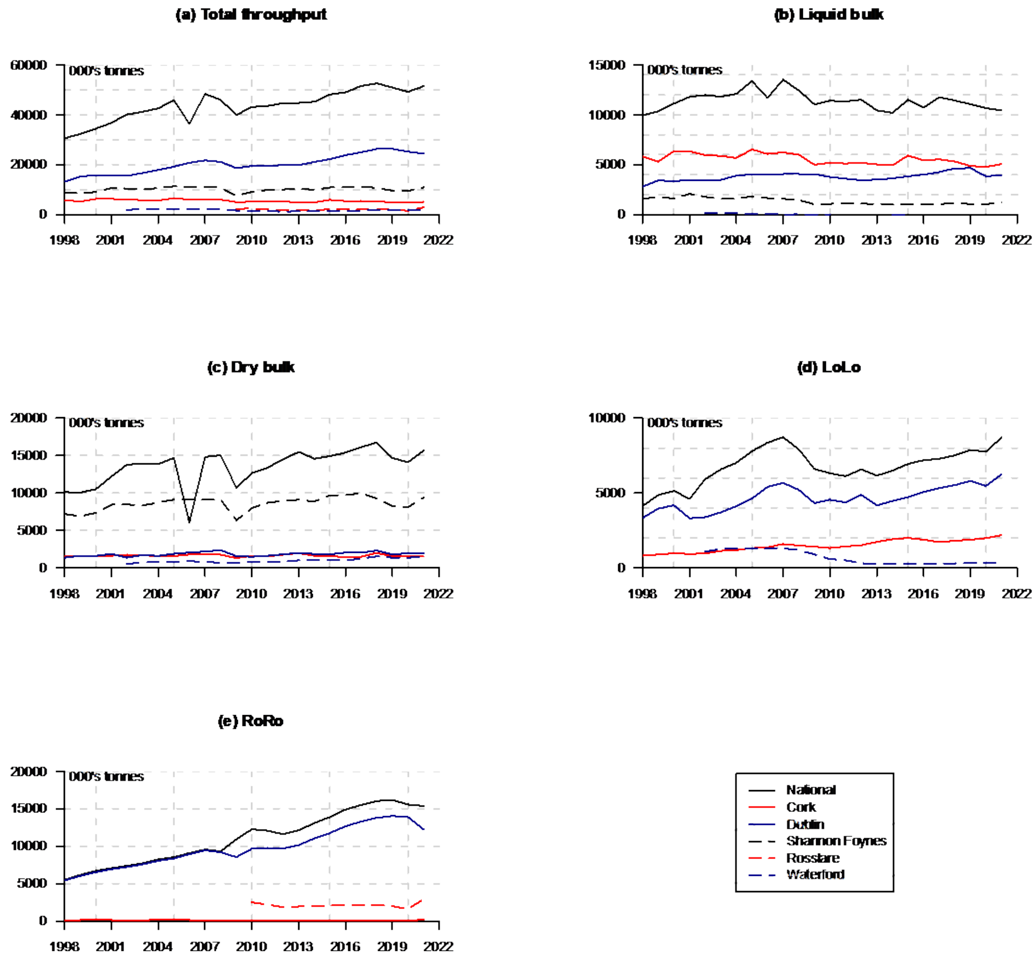

Figure 5: Irish port throughput 1998–2021

As shown in Figure 5, Ireland's main ports handle multiple types of cargo including roll on roll off (RoRo), lift on lift off (LoLo), dry bulk, and liquid bulk. Liquid bulk traffic at Irish ports has been in decline in recent years, reflecting a reduction in the use of liquid fossil fuels in favour of renewables and natural gas. While the use of renewables is set to increase in the coming years, Ireland still relies heavily on

[3] These estimates were produced by taking the average of each port’s annual share of national port throughput over the period 1998–2021.

imported fossil fuels for domestic production, household energy and transportation. Liquid bulk tonnage accounted for around 27% of total national port tonnage over the period 1998–2021. The majority of Ireland's liquid bulk cargoes were handled by the ports of Cork and Dublin, with each responsible for shipping around 50% and 33% respectively of national liquid bulk tonnage since 1998. Cork's share of national liquid bulk cargoes has remained relatively constant over the past two decades, while Dublin's share has increased marginally at the expense of Shannon Foynes. Shannon Foynes accounted for around 12% of Ireland's national liquid bulk tonnage since 1998. However, its share has declined in recent years, while its share of Ireland's dry bulk tonnage has been growing.

Dry bulk shipping handles a broad range of Irish exports and imports, transporting raw materials for industrial production and agriculture, and essential foodstuffs and solid fuels such as grain and coal to meet domestic food and energy demands. Dry bulk cargoes accounted for around 31% of total national port tonnage over the period 1998–2021, and with the exception of a temporary decline associated with the 2008 financial crisis, grew consistently at a national level over the past two decades. Shannon Foynes is Ireland's leading dry bulk port and handled around 66% of Ireland's dry bulk tonnage since 1998. Despite a temporary decline in 2019, the volume of dry bulk cargo at the port has been increasing since 2010. The ports of Dublin, Cork and Waterford also handle dry bulk cargoes, and have maintained average shares of about 14%, 13%, and 6% respectively of national dry bulk tonnage over the past two decades.

Container cargo is handled by the ports of Dublin, Cork, Rosslare, and Waterford. The vast majority of Irish manufactured exports and imports are transported via containers to Britain and continental Europe. Continental trade is conducted through a hub-and-spoke system where feeder vessels transport containers between Irish ports and large European ports such as Rotterdam and Antwerp, which serve continental markets or facilitate transoceanic voyages. Lift on lift off (LoLo) cargo accounted for around 16% of total Irish port tonnage between 1998–2021, and despite a significant decline following the 2008 financial crisis, LoLo tonnage has been growing since 2010. Recent growth in LoLo traffic has been driven by uncertainties surrounding the post Brexit trade arrangement between the EU and the UK and the consequent decline in the use of the UK Landbridge in favour of direct routes to the continent. The LoLo market is mainly served by the ports of Dublin, Cork and Waterford, which accounted for respective shares of around 69%, 22% and 9% of Irish LoLo tonnage since 1998.

Roll-on roll-off (RoRo) shipping also facilitates Irish containerised trade with Britain and continental Europe. RoRo shipping to the continent typically relies on the UK Landbridge, with goods first transported to UK ports located close to the east coast of Ireland, after which they take the British overland route south east to make a crossing to the continent at the Channel straits. The UK Landbridge is the shortest crossing to continental Europe, taking on average 20 hours, compared to direct RoRo and LoLo routes which take around 40 and 60 hours respectively (Breen et al., 2018). The majority of Irish RoRo cargo is handled by the ports of Dublin and Rosslare, both located on the east coast, a short distance from British ports. Irish RoRo traffic accounted for around 25% of total Irish port tonnage between 1998–2021, and achieved almost consistent growth over the last two decades, with only temporary declines in growth following the 2008 recession. More recently however, as mentioned above, there has been a decline in the use of the UK Landbridge as a result of uncertainties caused by Brexit. Dublin handles the vast majority of RoRo traffic and accounted for an average share of 90% of total national RoRo tonnage over the period 1998–2021, while Rosslare accounted for 15% since 2010.

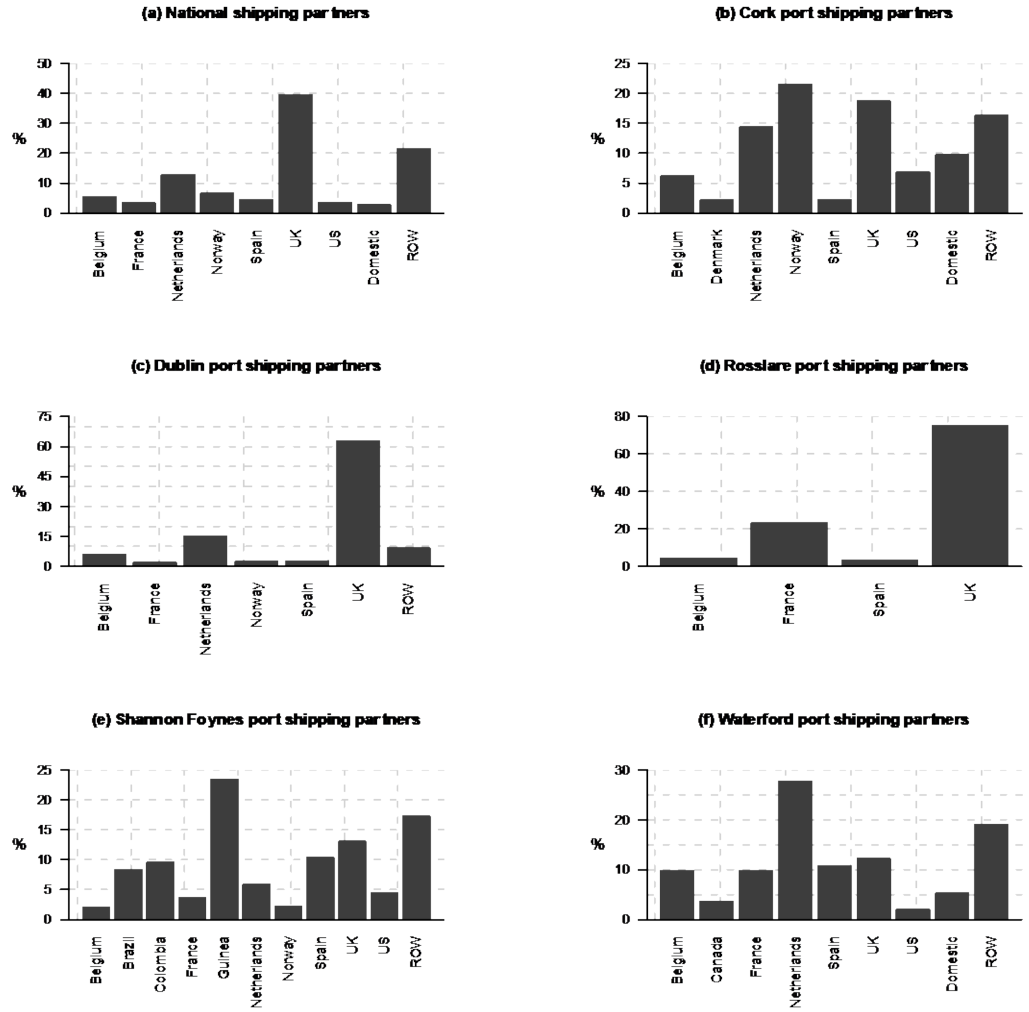

Figure 6: Average gross tonnage to/from port by region 1998–2021 (based on annual % of total throughput)

In Figure 6, we show the average gross tonnage shipped both to and from Ireland by partner over the period 1998–2021, both nationally and at port level. The countries listed in this chart are indicative of where goods were shipped to and from and not necessarily final trade partners. These data are important when assessing total fuel costs associated with maritime transport as they show the typical routes and distances travelled by vessels serving Irish trade, which are important determinants of total fuel costs. Panel (a) shows these data at national level, indicating that on average 40% of Irish port tonnage was shipped between Ireland and the UK over the period 1998–2021, making the UK Ireland's most important shipping partner by a significant margin. The Netherlands was Ireland's second most important shipping partner over this period, accounting for on average 13% of the gross tonnage shipped to and from Irish ports, while Belgium accounted for 5%, reflecting the importance of both Rotterdam and Antwerp as hub-and-spoke centres for Irish trade. Other European countries accounted for significant shares too, with Norway, Spain and France accounting for 6%, 5% and 3% respectively. The remainder, just over 20%, was divided between domestic shipping, which accounted for around 5%, and goods shipped to various other ports throughout the world. Countries such as the US, Brazil, Colombia, and Guinea were the most significant non-European shipping partners, although the level of goods shipped to these countries was relatively small compared to countries in Europe.

In panels (b)-(f), we show these data at port level for the ports of Cork, Dublin, Shannon Foynes, Rosslare and Waterford. These panels show that shipping partners differed significantly by port. For Dublin and Rosslare, the two largest east coast ports, the UK was by far the most important shipping partner, accounting for average shares of 62% and 74% respectively of the total tonnage shipped to and from both ports since 1998. The UK was also a significant shipping partner for the port of Cork, and was the third most important partner for the ports of Shannon Foynes and Waterford. The most important continental European shipping partners for Irish ports were Belgium and the Netherlands, again reflecting the important of these ports in the hub-and-spoke system between Ireland and the continent. Other European countries such as France, Denmark, Norway, and Spain were also significant shipping partners for most Irish ports.

Non-European regions, located in North America, South America and North Africa accounted for a substantial quantity of the goods shipped to and from the ports of Cork, Shannon Foynes and Waterford. The US was a significant shipping partner for these three ports. Shannon Foynes was the most diverse Irish port in terms of shipping partners, and aside from European and North American partners, it shipped goods to and from Brazil, Colombia and Guinea. Domestic shipping also accounted for sizeable proportions of the total goods shipped to and from the ports of Cork and Waterford. In contrast, domestic shipping accounted for only small percentages of the goods shipped at the ports of Dublin, Rosslare and Shannon Foynes.

3. The European Green Deal and the Fit for 55 package

The EU Green Deal (2019) aims to transform the EU into a fair, prosperous society with a modern, resource-efficient, competitive and carbon neutral economy by 2050 (EC, 2019). To support these efforts, the Fit for 55 package aims to translate the ambitions of the EU Green Deal into law. This package sets out a range of initiatives that aim to reduce carbon emissions by 55% by 2030 and achieve carbon neutrality by 2050, establishing the EU as a leader in the fight against climate change. The Fit for 55 package extends measures to sectors not previously subject to climate regulations and taxes. Among these is the maritime transport sector, which is responsible for 3-4% of all EU CO_2 emissions (around 144 million tonnes in 2018). To achieve the Fit for 55 targets, it is estimated that the maritime transport sector will need to reduce emissions by around 91-92% relative to 2015, and 89-90% relative to 1990 (EC, 2021b). Five directives of the Fit for 55 package apply to the maritime transport sector and may potentially affect costs for ports, shipping operators and maritime transport consumers. Due to the important role of maritime transport in facilitating intra and extra EU trade, cost increases may ultimately affect the macroeconomy through changes in consumer prices, demand, trade, output and employment. The five directives which directly apply to the maritime transport sector are the Alternative Fuel Infrastructure Directive (AFI), the Emissions Trading System Directive (ETS), the Energy Taxation Directive (ETD), the FuelEU Directive and the Renewable Energy Directive (RED).

The maritime transport fuel mix currently consists, almost exclusively, of liquid fossil fuels such as marine fuel oil. To date, the failure of RLFs to penetrate the maritime transport sector is due to a number of factors relating to costs, technology and supply issues. The substantial price gap between traditional fossil fuels and RLFs has been a major disincentive for the uptake of RLFs. This challenge has been compounded by legislative shortcomings enforcing RLF usage, and proportionate taxation based on energy intensity, which would help to lower the price gap between fossil fuels and RLFs. Uncertainty surrounding future regulatory requirements and the maturity of globally utilisable renewable technologies has also restricted the penetration of RLFs in the maritime transport sector. There is significant investment risk for first movers given the large capital costs and long average life span of vessels (21 years), creating a potential for stranded assets in the event of new technological breakthroughs which would render early alternative vessels less competitive. Overall, the combined effect of these factors has led to insufficient demand for RLFs in maritime transport and in order to achieve the 2030 and 2050 targets of the Fit for 55 package, higher RLF penetration rates will be necessary in the sector. The five directives listed above are designed to create the regulatory certainty and taxation framework necessary to reach these targets.

The FuelEU Directive will bring the most direct and dramatic change to the maritime transport sector. This directive aims to increase demand for RLFs, such as liquid biofuels, e-liquids, bio-LNG, e-gas, and decarbonised hydrogen fuels, in the maritime transport sector, achieving an RLF penetration rate in the total fuel mix of 6-9% by 2030 and 86-88% by 2050. As outlined in Table 1, three policy options, all applicable to vessels greater than 5000GT, have been proposed to achieve these targets. The first policy option would see mandatory RLF shares from 2025 set by regulation and defined in terms of the share of RLFs in the total maritime transport fuel mix. This policy option would see RLF shares increase from 7.4% of the total fuel mix in 2030 to 30% in 2040 and eventually 85.9% in 2050. The second option would set carbon intensity goals for maritime transport operators, with freedom of choice in terms of the use of fuels and technologies to achieve these goals. These targets would be set at -7% well-to-wake GHG intensity reduction in 2030, -26% in 2040 and -74% in 2050. Policy option three, the favoured option, is a similar approach to option two, with identical targets, but allows voluntary transfer and compensation of balances between ships and ship operators to reward over achievers.

Table 1: FuelEU policy options and targets

	2025	2030	2035	2040	2045	2050
P.O.1: Total RLF shares in the fuel mix (%)	2.9	7.4	15.6	30.0	68.8	85.9
P.O.2: Well to wake GHG intensity reduction (%)	-2	-7	-14	-26	-59	-74
P.O.3: Well to wake GHG intensity reduction (%)	-2	-7	-14	-26	-60	-75

Source: FuelEU Impact Assessment Report (EC, 2021b).

Increased demand for RLFs should bring forth increased supply and therefore through scale economies lower the price gap between RLFs and traditional fossil fuels, further incentivising the usage of RLFs in the sector. However, scale economies alone will likely not be enough, particularly in the short-term, to sufficiently lower the price gap between RLFs and traditional fossil fuels. Therefore, the Fit for 55 package includes revisions to three other directives, the Emissions Trading System Directive, the Energy Taxation Directive, and the Renewable Energy Directive which are designed to further disincentive the use of fossil fuels by introducing additional taxation on fossil fuel usage in maritime transport, which will help to reduce the price gap between RLFs and fossil fuels in the sector.

The EU's Emissions Trading System (ETS) is a cap-and-trade system which limits carbon emissions, requiring that allowances be purchased to cover greenhouse gas emissions in excess of the cap. Since 2005, the cap on emissions was lowered by 1.7% per annum to reach a 2020 emissions reduction target of 21% on 2005 levels. The ETS has proven effective in reducing emissions, achieving a 35% reduction in emissions between 2005–2019, 14% above its 2020 target. To date, the maritime transport sector has been exempt from the cap-and- trade system of the ETS. However, to meet the revised climate ambitions of the Green Deal, the ETS will be extended to the maritime sector. There are several proposed options for this extension, including integrating the maritime transport sector into the current ETS, the establishment of a separate ETS for the maritime transport sector, or by combining annual levy payments on ship operators based on CO_2 emissions. All options would result in higher maritime transport costs arising from higher ship operating costs to cover emissions, and from higher capital costs associated with the retrofitting of vessels to support renewable and alternative fuels. It is estimated that under a separate maritime transport ETS, ship operators could pay up to €268 per tonne of CO_2 emissions, and in the long term all potential policies which extend the ETS to the maritime transport sector would lead to a cost increase for ship operators of 16-20% by 2050.

The Energy Taxation Directive (ETD) has a number of shortcomings with respect to taxation methods and disparities in tax rates across EU member states. Fuel consumption is currently taxed on the basis of volume rather than energy content or intensity. The volume taxation method *de facto* favours fossil fuels as they have a higher energy intensity, meaning that a lower quantity of fossil fuels would be required to travel a set distance, resulting in a higher effective taxation level for RLFs.

Another major shortcoming of the current ETD arises from minimum taxation rates, which are based on 2003 inflation levels. This has led to low and inconsistent levels of effective energy taxation across member states. Revisions to the current ETD will address taxation methods, taxing fuel consumption based on intensity, and reset minimum taxation rates in line with current levels of inflation. The revised ETD will also be extended to the maritime transport sector which to date has largely been exempt from carbon taxes. However, given its role in facilitating EU trade, a minimum zero rate will be imposed on the sector, with each EU member state retaining the option to introduce unilateral changes to fuel taxation in maritime transport. The introduction of these taxation methods to the maritime transport sector will help to lower the price gap between fossil fuels and RLFs, and incentivise the uptake of RLFs in the sector, but will lead to increased fuel costs for ship operators, with estimated cost increases of 1.2% for transport fuel prices (EC, 2021d).

The Renewable Energy Directive has also been revised to reflect the new targets established under the EU Green Deal. The revisions increase the target for the share of renewable energy as part of the overall energy mix from 32% to at least 40% by 2030. It also outlines a framework for the development of renewables for all sectors of the economy, in order to promote an integrated energy system. It aims to make renewables more flexible, allowing them to penetrate difficult to decarbonise sectors like transport, buildings, and industry. In the transport sector, the proposal introduces a 13% target for reductions in greenhouse gas intensity of transport fuels by 2030, equivalent to an energy-based target of 28%, effectively doubling the 14% target set by REDII.[4] As the cost of RLFs is higher than traditional fossil fuels, the new targets could have a substantial impact on costs in the maritime transport sector, increasing fuel prices for ship operators, which will likely be passed on to consumers.

Maritime transport costs will also be affected by the Alternative Fuel Infrastructure (AFI) Directive, which sets targets for the rollout of recharging and refuelling infrastructure across member states for all transport nodes to support the climate change ambitions of the Green Deal. In the maritime transport sector, the AFI directive requires the provision of onshore power supply (OPS) for at least 90% of demand from vessels greater than 5000GT at all TEN-T core and comprehensive ports by 2030, and Liquified Natural Gas (LNG) refuelling stations at all TEN-T core ports by 2030. The provision of these infrastructures will carry large capital and operating costs for ports. Capital costs will arise from the need for the construction of buildings and shelters, and technical equipment such as switchgear, transformers and frequency converters, and will range from €1 million to €25 million per port for OPS, and €0.2 million to €100 million for LNG, depending on port size and demand. Total operational costs will also vary depending on the level of demand at each port, but are estimated at €4,300 per MW of onshore power capacity. Both the capital and operational costs incurred by ports are likely to be passed on to ship operators and ultimately consumers.

[4] EC 2021 https://ec.europa.eu/info/news/commission-presents-renewable-energy-directive-revision-2021-jul-14_en

4. Methodology

International trade flows are influenced by a range of factors, including, *inter alia,* the business cycle, exchange rates, trade policies, cultural connections and transportation costs. Transportation costs are determined by several factors, including distance between markets, geography, infrastructure, trade facilitation, transport technology and fuel costs (Anderson and Van Wincoop, 2004; Behar and Venables, 2011). In this study, we focus on the effect of fuel costs on trade, the maritime transport sector and the broader economy. Maritime transport relies heavily on liquid fossil fuels that are oil based, and therefore the cost of fuel in the maritime sector is closely correlated with developments in international oil markets, with supply and demand factors exerting a considerable influence on overall fuel costs. Along with developments in global oil markets, distance and taxation are major determinants of the overall cost of fuel in the maritime transport sector. Greater distance between producers and consumers means longer transit times and higher fuel consumption and fuel costs. Rising environmental awareness in recent decades and the subsequent introduction of regulations such as taxes on CO_2 and other greenhouse gas emissions have also affected fuel prices and output in sectors that rely heavily on fossil fuels.

Increased fuel costs and transport costs can negatively impact trade flows, and produce spill-over effects on the maritime transport sector and the broader economy, with changes in trade affecting prices, national output, consumer spending and employment. Increased transportation costs arising from fuel regulations and transport taxes raise the cost of exporting and importing final goods, as well as importing intermediate goods and raw materials for domestic producers. Higher costs make firms less competitive relative to other countries with less stringent taxation or regulations on traditional fossil fuels, leading to a fall in demand, income and employment. Depending on demand elasticities, firms may also pass on increased costs to consumers leading to higher costs for households and lower welfare. In the case of environmental taxation, the net impact of these types of taxes on economic activity depends in part on how tax revenues are redistributed. If taxation policy is neutral and there is no change in the government budget position, receipts from environmental taxes can be used to reduce distortionary taxes on income and consumption, thereby boosting economic activity. This produces a double-dividend effect whereby negative externalities relating to carbon emissions and pollution are reduced while national income is increased. However, if taxation policy is not neutral, or if new revenues are not used to lower consumption or income taxes, then environmental taxation can have a negative effect on both consumers and producers and lead to lower demand, trade, output and employment (Bernard et al., 2018).

Several studies have examined the determinants of transportation costs, as well as the impacts of changes in transportation costs and the imposition of environmental taxation on economic growth, trade and employment. The results of these studies are mixed. Hummels (1999) estimated an elasticity coefficient for transport costs with respect to distance of 0.22 for sea transport, while Beverelli et al. (2010) estimated a coefficient elasticity of 0.19-0.36 for transport costs with respect to fuel prices for container and oil shipping, and found that dry bulk shipping is more sensitive to changes in fuel prices. Nanovsky (2019) estimated a gravity model which tests the response of global trade to oil price changes, finding that as oil prices increase international trade becomes more localised, while it becomes more dispersed as oil prices fall. Abdullah and Morley (2014) tested the impact of environmental taxes on economic growth using a panel of OECD countries over the period 1995-2006, and found that environmental taxes had no statistically significant impact on economic growth. Using a VAR model and impulse response functions, Bernard et al. (2018) found that a shock to gasoline prices significantly affected GDP per capita in the Canadian province of British Columbia.

Elgie and McClay (2013) examined the impact of environmental taxation on output growth in British Columbia and found that it had no significant effect on GDP. Others have studied the impact of carbon taxes on households and employment. Goulder et al. (2019) use a general equilibrium model to examine the effect of carbon taxes on US household income. They find that the positive effects of carbon taxes on wages, capital and transfer incomes outweigh the negative effect of the tax on the price of goods and services for households. Beck et al. (2015) use a general equilibrium model to examine the distributional impacts of carbon taxes on households in British Columbia and find a very small impact on aggregate household welfare of 0.08%. Yamazaki (2017) and Yip (2018) examined the labour market effects of carbon taxation in British Columbia. Yamazaki (2017) find that carbon taxation negatively affected total labour income by 0.3-0.9%, while Yip (2018) finds that the carbon tax added 1.2-1.3% to total employment.

We follow the approach of previous studies (Bernard et al., 2018; Kilian and Vigfusson, 2011, 2013) by adopting a VAR model to estimate the impact of changes in fuel prices on output, prices and employment. To capture fully the impact of changes in fuel prices over time and control for possible endogeneity, we include several lagged values of the dependent, independent and control variables, with the total number of lags selected to minimise the BIC test statistic. Using real exports as an example, our VAR model examines the response of real exports to lagged changes in marine fuel oil prices:

$$\Delta REX_t = \alpha + \sum_{i=1}^{K} \beta_{11,i}\, \Delta REX_{t-i} + \sum_{i=1}^{K} \beta_{12,i}\, \Delta FP_{t-i} + Z'\gamma + \mu_{it}$$

$$\Delta FP_t = \alpha + \sum_{i=1}^{K} \beta_{11,i}\, \Delta FP_{t-i} + \sum_{i=1}^{K} \beta_{12,i}\, \Delta REX_{t-i} + Z'\gamma + \eta_{it} \qquad (1)$$

where ΔREX_t is the change in real exports at time *t*, ΔREX_{t-i} are lagged changes in real exports and ΔFP_{t-i} are lagged changes in real marine fuel oil prices. $Z'\gamma$ is a vector of control variables to account for possible endogeneity, as fuel price changes are likely correlated with changes in other factors which determine Irish trade such as foreign income. We adapt our regressions with respect to our dependent variable in each specification of the VAR model, including control variables which are theoretically appropriate. We estimate regressions for output, GVA and employment for the maritime transport sector, as well as for Irish national income (real GNP), exports of goods, imports of goods, consumer prices (CPI) and employment.

Table 2: VAR regression specifications

Dependent variable	Independent variables	Control variables
GNP	Marine fuel price	EU GDP
Exports (goods)	Marine fuel price	Real effective exchange rate, EU GDP
Imports (goods)	Marine fuel price	Consumption, Real effective exchange rate
CPI	Marine fuel price	EU CPI, UK/Irish nominal exchange rate
Employment	Marine fuel price	Exports (goods)
Consumption	Marine fuel price	Employment, CPI
Maritime transport sector output	Marine fuel price	Total trade (goods), consumption, real effective exchange rate
Maritime transport sector GVA	Marine fuel price	Total trade (goods), consumption, real effective exchange rate
Maritime transport sector employment	Marine fuel price	Total trade (goods), consumption, real effective exchange rate

Note: GNP, EU GDP, total trade (goods), exports (goods), imports (goods), consumption, and marine fuel prices are real values. All variables refer to Irish statistics except where stated. The marine fuel price used in this study is the price per tonne of Heavy Sulphur Fuel Oil at Rotterdam.

Table 2 shows the control variables used in each specification. Because of the well-known distortions affecting Ireland's GDP data, we avoid using Irish GDP as a control variable. We instead use control variables for economic activity such as real consumption, employment, real trade flows, and other influential factors like exchange rates that are likely more directly related to the domestic economy. Our full set of control variables includes the Irish real effective exchange rate, the nominal exchange rate between the UK and Ireland, EU real GDP, EU CPI and Irish CPI. In our real GNP regression, we control for lags of domestic and foreign income to account for lagged growth effects and the influence of international factors on the Irish economy. For real trade flows, we control for lags of real consumption, foreign income which affects demand for Irish exports, and the Irish real effective exchange rate which is a measure of the competitiveness of Irish goods relative to foreign goods. For CPI, we control for EU inflation to account for pass-through to Irish prices, as well as the UK/Irish nominal exchange rate as a significant share of consumption goods sold in Ireland are imported from the UK. For real consumption, we control for employment and the price level, as both directly determine household consumption levels. In regressions for the maritime transport sector, we control for total real trade, real consumption and the Irish real effective exchange rate. In all regression specifications, we use heteroskedasticity and autocorrelation robust standard errors.

In the system of equations outlined above, we also include an equation in which real marine fuel prices is the dependent variable, as is standard in a VAR system. We expect Irish trade and output to have little or no effect on marine fuel prices as these prices are determined internationally by developments in global oil and shipping markets. However, using a VAR model as outlined above allows us to estimate impulse response functions, which show the response of the dependent variables in a VAR model to shocks in the error terms, μ_{it} and η_{it} in the above system of equations.

In this case, it allows us to examine the impact of a marine fuel price shock on both the Irish maritime transport sector and the broader Irish economy, and the dynamic effect of the shock on output and employment in the maritime transport sector and the economy more broadly.

5. Data

In this section, we present and summarise the data used to conduct our VAR analysis and projections of the impact of future changes in marine fuel prices on the maritime transport industry and the Irish economy. Our data are quarterly and the sample period for our historical analysis runs from Q1:1995 to Q4:2020. Data on all variables with the exception of marine fuel prices are taken from public databases, including Eurostat, Ireland's Central Statistics Office (CSO) and the Federal Reserve's FRED database. In the charts below, we present all variables in levels, but as VAR modelling requires data to be stationary, the summary statistics presented in Table 3 refer to quarterly percentage changes for each variable.

In Figure 7, we show data on the price of Heavy Sulphur Fuel Oil at Rotterdam, sourced from Clarkson Shipping Intelligence Network. Heavy sulphur fuel oil was one of the most commonly used marine fuels over the past three decades and therefore serves as a good indicator of overall changes in marine fuel prices for our sample period. Marine fuel prices increased from the late 1990s, before peaking at €532 per tonne around 2008. In the aftermath of the GFC, marine fuel prices dropped but subsequently recovered from 2010. Since then, prices have fluctuated between €150-€300 per tonne. The average quarterly change in marine fuel price was around 0.92% over the period 1995-2020. However, fuel price changes were fairly volatile, with a standard deviation of 17%.

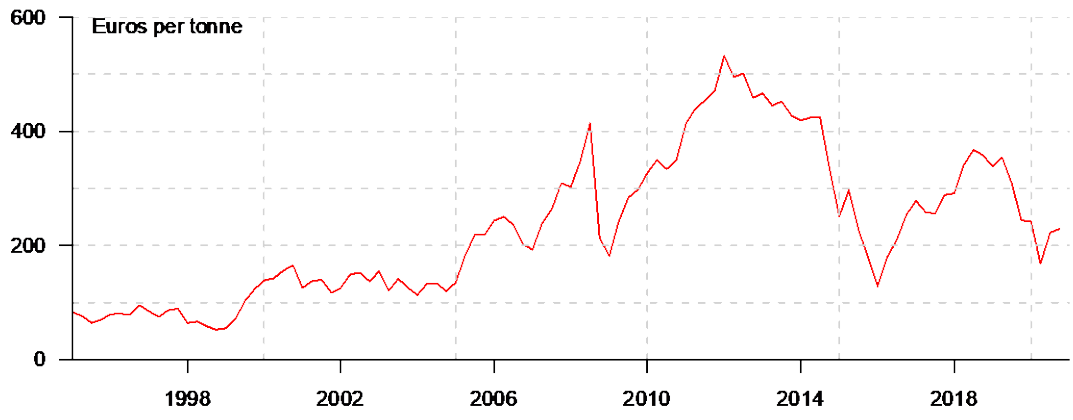

Figure 7: Heavy sulphur fuel oil price (Rotterdam) 1995–2020

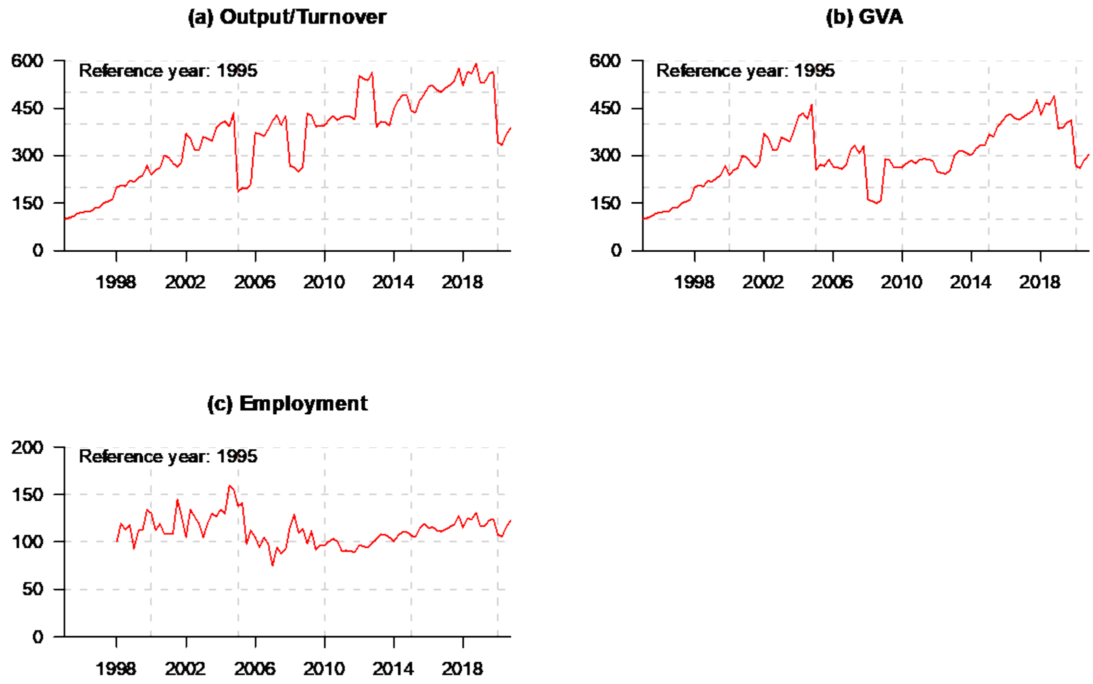

Figure 8: Maritime Transport Output/Turnover, GVA, and Employment indexes 1995–2020

Data on output, GVA and employment in the maritime transport sector were collected from the databases of the CSO and Eurostat, and from SEMRU reports on Ireland's Ocean Economy (SEMRU, 2013, 2015, 2017, 2019, 2022). In these reports, SEMRU calculate the annual turnover (output), GVA and employment of the Irish maritime transport sector using data for the following NACE Four-Digit Codes: 50.10 (Sea and coastal passenger water transport), 50.20 (Sea and coastal freight water transport), 52.22 (Service activities incidental to water transportation), 52.24 (Cargo handling), 52.29 (Other transportation support activities), and 77.34 (Renting and leasing of water transport equipment). Four-digit level data are available only from 2010, so for the period prior to this year we rely on data for Water Transport (NACE code 50), which typically mirrors overall trends for the sector. To construct a quarterly measure of these variables, we weight the annual figures according to the level of trade in each quarter, and then splice both the Water Transport and SEMRU data together in an index, with 2010 used as the overlap on which we base our link factor. Our indexes for output/turnover, GVA, and employment in the maritime transport sector are presented in Figure 8. The average quarterly change in our output/turnover, GVA and employment indexes was 5.80%, 5.62% and 4.71% respectively.

Our macroeconomic variables are presented in Figures 9 and 10. Figure 9 shows Irish real GNP, real consumption, real exports, real imports, CPI and employment, which are the dependent variables in different specifications of our VAR analysis outlined above. The trends across all of these variables are similar, with growth in the period before the global financial crisis, declines from 2008, followed by recovery from around 2014. Of these variables, exports and imports were the most volatile, as shown in Table 3. GNP was less volatile than changes in trade, but was more volatile than employment.

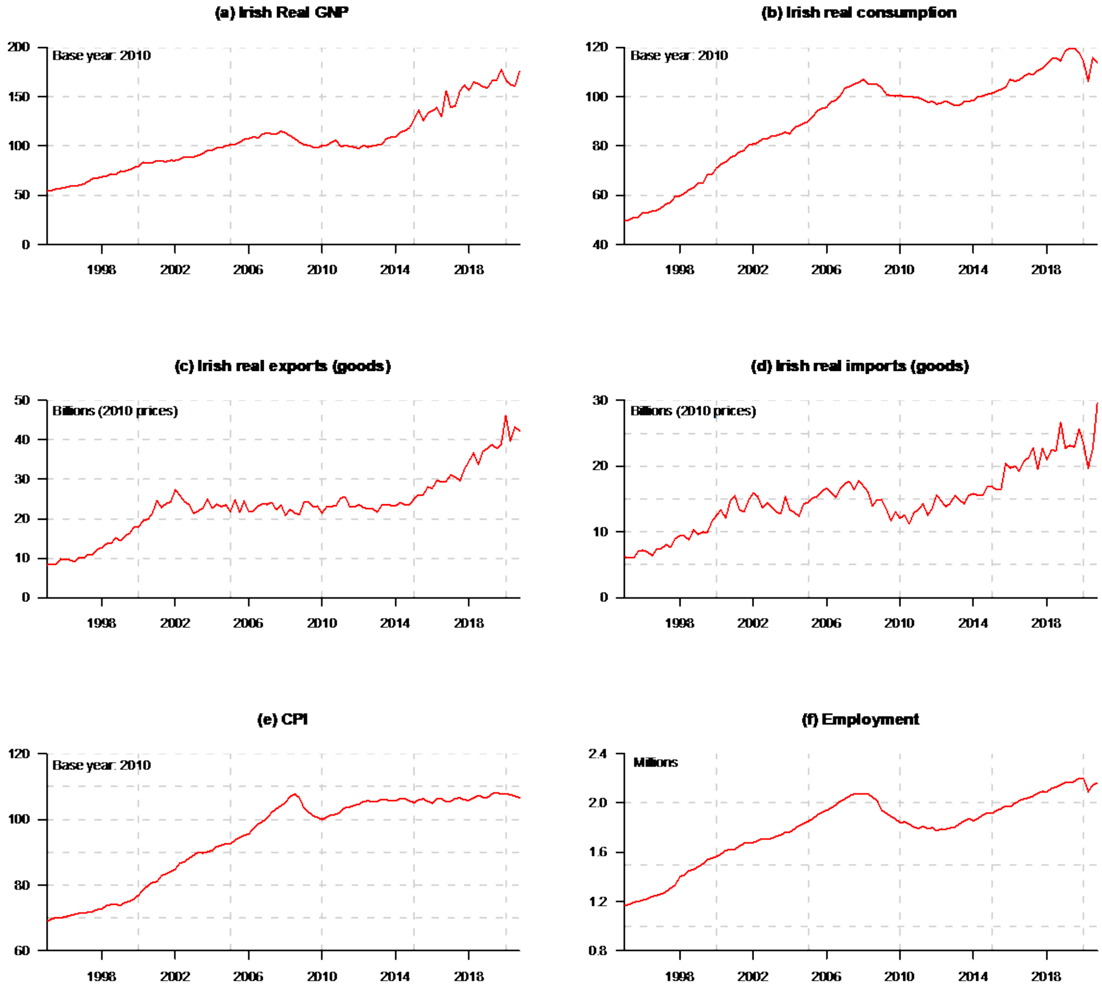

Figure 9: Irish real GNP, real consumption, real exports (goods), real imports (goods), CPI, and employment 1995–2020

In Figure 10, we show the control variables used in our VAR models, the Irish real effective exchange rate index, the Irish/UK nominal exchange rate, EU real GDP and EU CPI. The Irish real effective exchange rate is an inflation adjusted weighted average of the value of the Irish pound and later the Euro relative to the currencies of Ireland's trading partners. It is an indicator of Ireland's international competitiveness, with an increase in the index suggesting that Irish goods became less competitive, with exports more expensive on foreign markets and imports more affordable in domestic markets. Irish traded goods became less competitive in early 2000s, but gradually regained competitiveness as the economy adjusted in the years following the financial crisis. The Irish nominal exchange rate *vis-à-vis* the UK has been found to be an important determinant of inflation in Ireland. Sterling appreciated in value against the euro in the period shortly after the introduction of the single currency, but weakened significantly during the 2008 financial crisis and has traded in a narrow range since then.

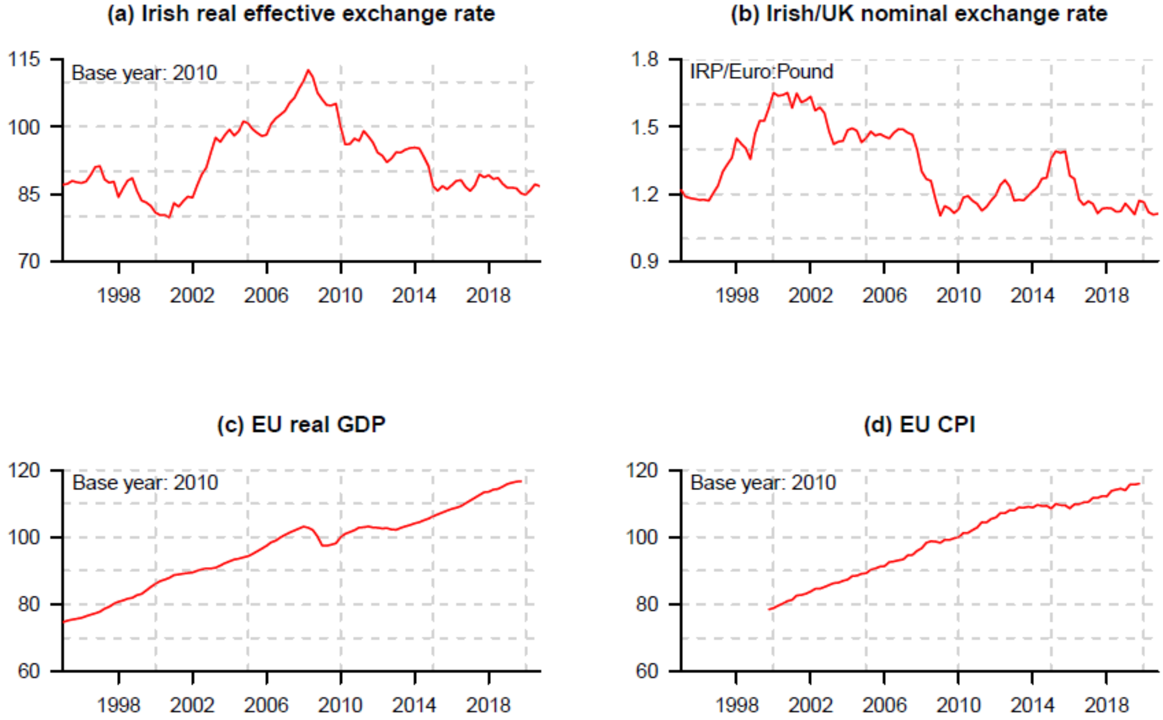

Figure 10: Irish real effective exchange rate, Irish/UK nominal exchange rate, EU real GDP, and EU CPI 1995–2020.

Table 3: Summary statistics: quarterly percentage changes

Variable	Mean	Standard Deviation	Minimum	Maximum
Real GNP	1.15	3.70	-11.83	18.86
Real consumption	0.80	1.79	-7.46	8.73
Real exports	1.58	6.67	-15.43	17.49
Real imports	1.52	9.36	-16.95	27.18
CPI	0.51	1.08	-4.5	2.7
Employment	0.60	1.21	-4.99	4.91
Real effective exchange rate	0.26	1.67	-4.58	3.51
UK/Irish nominal exchange rate	0.10	3.97	-8.21	27.03
EU real GDP	0.36	0.46	-2.42	0.95
EU CPI	0.47	0.57	-0.96	1.74
Water Transport output	1.07	18.28	-85.62	90.90
Water Transport GVA	0.14	14.83	-72.77	60.70
Water Transport employment	0.10	13.65	-36.77	28.77
Marine fuel oil price per tonne (Rotterdam)	0.92	17.34	-79.69	36.30

Real EU GDP and CPI are presented in panels (c) and (d) of Figure 10. These variables follow similar patterns to their Irish counterparts, reflecting the influence of external conditions on the Irish economy. The volatility of EU GDP, however, was much lower than Irish GNP. The high volatility of Irish output relative to EU output again highlights the potential problems associated with using Irish output figures as control variables. Irish CPI was also more volatile than its EU counterpart, although the margin was considerably less than the relative volatility of output.

Table 4: Projected fuel prices, € per tonne of oil equivalent (toe)

Fuel prices €/*toe*	2025	2030	2035	2040	2045	2050
Liquid fossil fuels	627	627	686	744	803	861
LNG	608	608	635	662	688	715
Biofuels	1301	1301	1289	1277	1264	1252
Bio-LNG	868	868	896	923	951	978
e-liquids	2285	2285	2128	1972	1815	1658
Liquid hydrogen	1467	1467	1467	1467	1467	1467
Ammonia	1467	1467	1467	1467	1467	1467
e-gas	2220	2220	1975	1729	1484	1238
Electricity	1698	1698	1690	1682	1673	1665

To forecast the impact of the gradual switch from fossil fuels to RLFs from 2025–2030, we calculate the price gap between a fuel mix entirely comprised of liquid fossil fuels and the 'FuelEU' mandated fuel mix. To do this, we use fuel price projections per tonne of oil equivalent (*toe*) shown in Table 4 and the mandated shares of RLFs and liquid fossil fuels to be used in the 'FuelEU' maritime fuel mix (shown previously in Table 1). Using these figures, we derive a weighted average price per *toe* of the FuelEU fuel mix and calculate the cost difference per *toe* between this fuel mix and one solely comprised of liquid fossil fuels. The price gap between both fuel mixes is the price shock we use, along with the coefficients of our VAR model and impulse response functions, to forecast the impact of the Fit for 55 package on the maritime transport sector and the Irish economy. The prices per *toe* of both fuel mixes are presented in Figure 11, and the price gap between both is shown in Figure 12, with all the associated data shown in Table 5.

Table 5: Projected liquid fossil fuel/FuelEU fuel mix price gap per toe

Fuel	2025	2030	2035	2040	2045	2050
Liquid fossil fuel (€/*toe*)	627	627	686	744	803	861
FuelEU mix (€/*toe*)	640	664	768	891	1114	1193
Price gap (%)	2	6	11	17	28	28

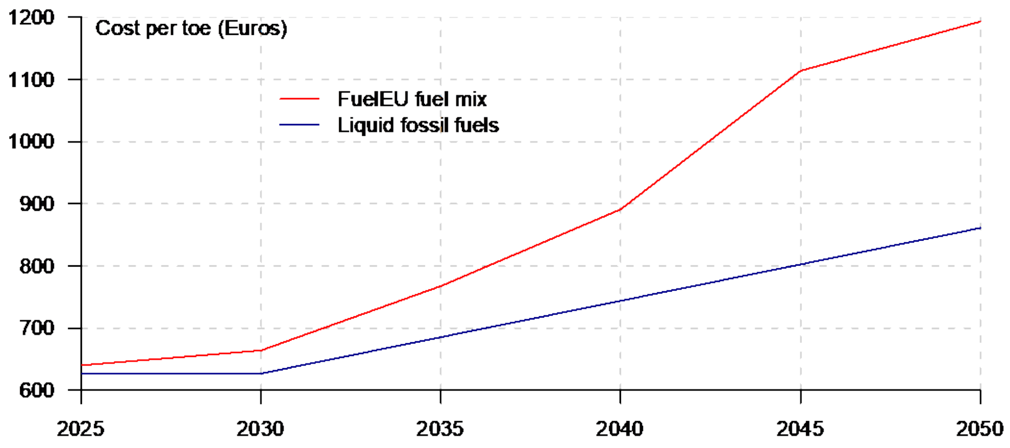

Figure 11: Fuel mix cost per toe 2025–2050

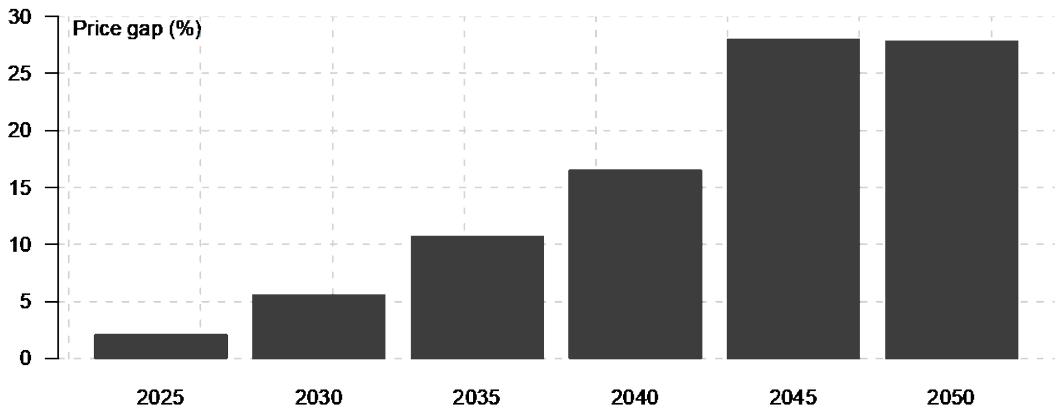

Figure 12: Fuel mix price gap 2025–2050

The price gap between liquid fossil fuels and the FuelEU fuel mix increases gradually over the period 2025–2050, reflecting the gradual increase in RLFs shares in the maritime transport fuel mix as outlined in the FuelEU directive. In 2025, the price gap is projected to be about 2%. This is projected to rise to 6% by 2030, before increasing to 11% by 2035. From 2035, the fuel price gap increases substantially to 17% by 2040 and 28% by 2045, before stabilising at this level.

6. Results and discussion

In this section, we assess the cost impact of the AFI directive on Irish ports, present the results of our VAR models, and use these results to project the impact of fuel price changes on the Irish maritime transport sector and the broader Irish economy. We first assess the cost of the installation and operation of onshore power facilitations at Irish ports, estimating the associated capital and annual operating costs for each of Ireland's five largest ports. We then present the results of our VAR models, outlining the historical impact of fuel price changes on both the Irish maritime transport sector and Irish macroeconomy. Finally, we use the estimated coefficients of our VAR models and the projected price gap between fossil fuels and RLFs to forecast the joint impact of the Fit for 55 package on sectoral output, GVA and employment in the maritime transport sector, and Irish real GNP, real trade, real consumption, CPI, and employment from 2025–2050.

6.1 The impact of the Fit for 55 package on the Irish maritime transport sector

Impact of the Alternative Fuel Infrastructure (AFI) Directive

The Alternative Fuel Infrastructure (AFI) directive mandates that onshore power supply (OPS) must be made available for 90% of ships greater than 5000GT while at berth at all EU TEN-T core and comprehensive ports by 2030. The provision of OPS at Irish ports will carry significant capital and operating costs that must be bore by ports and ship operators. Ports will be responsible for the construction and maintenance of infrastructure and operating costs associated with the use of OPS. In the AFI directive, the EU Commission estimate that capital costs for the construction of buildings and shelters, and for technical equipment such as switchgear, transformers and frequency converters, will range from €1 million to €25 million per port depending on port size and activity levels. The Commission estimate an average capital cost per MW of onshore power supply installed of €1.2 million for Ro-Pax vessels. Annual operating costs will also vary depending on the level of activity at each port, but are estimated at €4,300 per MW of onshore power supply installed.

Assuming all ships use OPS while at berth, Winkel et al. (2016) estimate the demand for OPS at European ports using a top down approach based on the type and size of ships, number of ship calls at each port, average hoteling times, typical fuel and electricity consumption per ship type and size, and the efficiency of auxiliary engines. We use these demand projections along with cost projections presented in the AFI directive as a baseline to calculate the capital costs of installing OPS infrastructure at Irish ports, and the associated annual operating costs.

In Table 6, we reproduce the demand estimates for OPS presented in Winkel et al. (2016), which show that OPS demand projections for Irish ports vary as expected by port size. Dublin has the largest demand, estimated between 201-300 gigawatt hours annually, while all other major Irish ports including Cork, Shannon Foynes, Rosslare, and Waterford, have estimated OPS demand levels of up to 30 gigawatt hours annually.

Table 6: Shore side electricity projections 2020

Port	Cork	Dublin	Shannon Foynes	Rosslare	Waterford
Annual shore side electricity demand GWh/a	0-30	201-300	0-30	0-30	0-30

Source: Winkel et al. (2016), Figure 2.

The annual demand figures estimated by Winkel et al. (2016) convert to a demand for 201,000-300,000 megawatt hours annually for Dublin and 0-30,000 megawatt hours annually for Cork, Shannon Foynes, Rosslare and Waterford. Assuming maximum use of installed capacity throughout the year, we estimate that Dublin will require 23-34MW onshore power capacity, and Cork, Shannon Foynes, Rosslare and Waterford will require 1-3.5MW onshore power capacity. The AFI impact assessment report estimates average capital and operational costs per MW of €1.2 million and €4,300 respectively. Along with estimated demand projections by Winkel et al. (2016) these average cost estimates imply a capital cost of between €27.6 million and €40.8 million and an annual operating cost of between €98,900 and €146,200 for Dublin, and between €1.2 and €4.2 million for capital and between €4,300 and €15,050 for operational for Cork, Shannon Foynes, Rosslare and Waterford.

Table 7: Shore side electricity cost estimates

Port	Cork	Dublin	Shannon Foynes	Rosslare	Waterford
Capital cost (euro millions)	1.2-4.2	27.6-40.8	1.2-4.2	1.2-4.2	1.2-4.2
Annual operating costs (euro)	4,300-15,050	98,900-146,200	4,300-15,050	4,300-15,050	4,300-15,050

Impact of Fuel Price Changes

The results of our VAR models for the maritime transport sector are presented in Table 8. Broadly speaking, these results show that changes in marine fuel price had a significant impact on the sector over the period 1995–2020. Fuel price increases typically reduced sector output and GVA over this period, with a 1% increase in marine fuel prices typically causing output to fall by 0.19% and GVA by 0.27% in the following quarter. However, fluctuations in marine fuel price appear to have had little effect on employment in the sector. Overall, the impact of fuel price changes was typically short-lived, with the significance of the lagged coefficients suggesting that they mainly affected the maritime transport sector in the first quarter following a price change.

Table 8: Maritime transport sector, VAR results

	Output	GVA	Employment
Constant	0.01	0.01	0.00
Real fuel price (-1)	-0.19**	-0.27***	0.06
Real fuel price (-2)	0.04	0.02	-0.04
R^2	0.13	0.16	0.17
Quarter			
1	-0.19	-0.27	0.06
2	0.08	0.04	-0.04
3	0.08	-0.07	0.0008
4	-0.002	0.007	-0.002
5	-0.008	-0.002	0.008

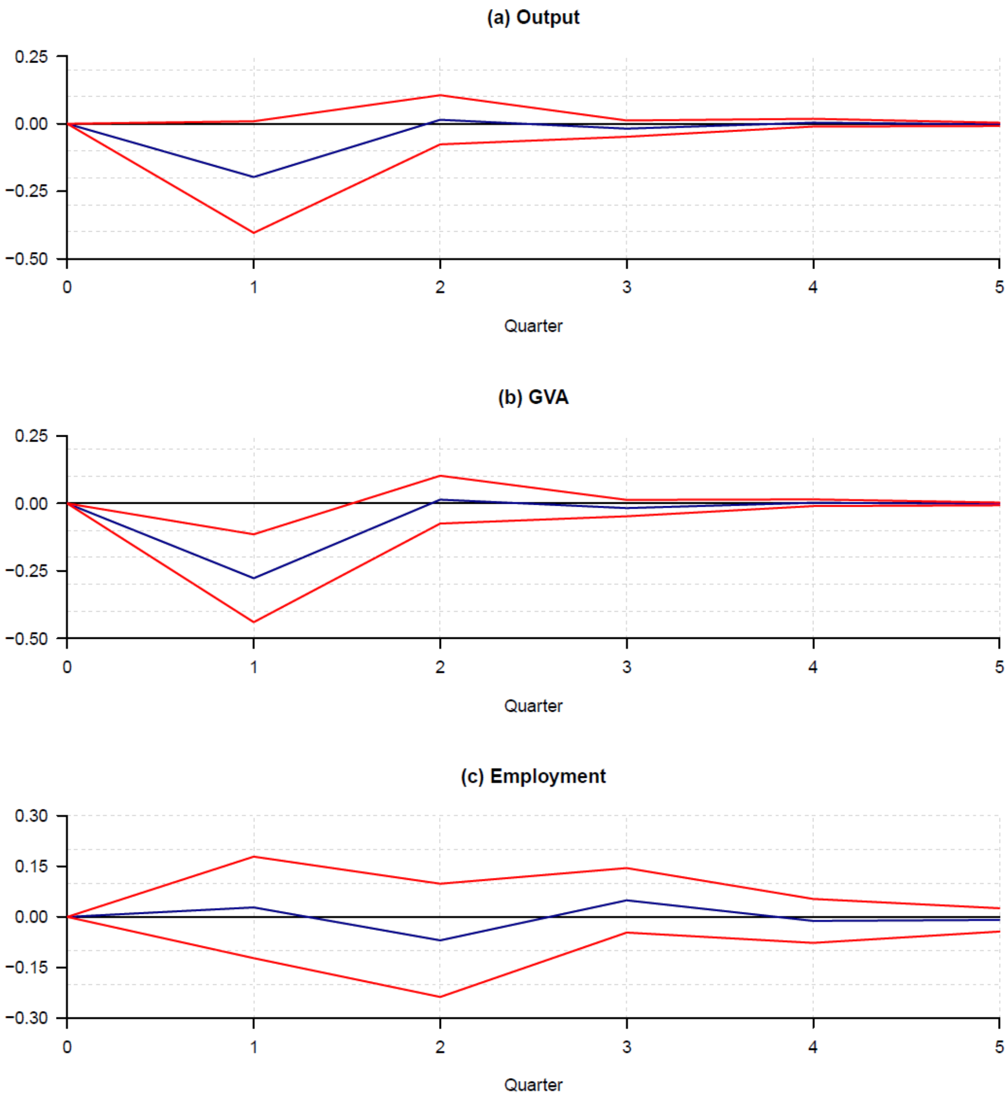

Figure 13: Impulse response functions maritime transport sector

In Figure 13, we plot impulse response functions that show the reaction of output, GVA and employment in the maritime transport sector to shocks to the price of marine fuel. These charts and the impulse response coefficients reported in Table 8 confirm that the effect of shocks to marine fuel prices on output, GVA and employment in the maritime transport sector were typically short-lived, and died out after around two quarters. We sum the impulse response coefficients, which combined show the long-run impact of marine fuel price shocks on output, GVA and employment, and use these long-run coefficients to forecast the impact of the gradual switch from fossil fuels to RLFs in 2025, 2030, 2035, 2040, 2045, and 2050.

The fuel price shock resulting from the Fit for 55 measures is the projected price gap per tonne between liquid fossil fuels and the FuelEU fuel mix. As outlined in the previous section, this price gap is expected to range from 2% in 2025 to 28% in 2050 with the price gap increasing substantially from 2035. Table 9 shows the projected impact of these price shocks on output, GVA and employment in the maritime transport sector. The results of our VAR models suggest that fuel price changes will have a significant effect on output and GVA in the sector, relative to a baseline scenario in which only liquid fossil fuels are used in the maritime fuel mix.

The impact on output ranges from -0.39% in 2025 to -5.29% in 2050, increasing gradually by about 1% with each successive increase in the RLF share of the maritime fuel mix until 2040, after which a shift to considerably higher shares of RLFs is expected to result in a 5.3% decrease in output in both 2045 and 2050. For GVA, the fuel price shock is expected to have a greater impact, ranging from -0.56% in 2025 to -7.52% in 2050. Again the increase in the share of RLFs in the fuel mix will gradually increase the magnitude of the impact on GVA, with the impact roughly doubling between 2030 and 2035, increasing by almost 2% between 2035 and 2040, and increasing by just over 3% between 2040 and 2045.

Table 9: VAR maritime transport sector projections (from baseline)

Year	Output	GVA	Employment
2025	-0.39**	-0.56***	0.12
2030	-1.06**	-1.51***	0.34
2035	-2.03**	-2.89***	0.64
2040	-3.14**	-4.46***	0.99
2045	-5.31**	-7.55***	1.68
2050	-5.29**	-7.52***	1.67

6.2 The impact of the Fit for 55 package on the Irish macroeconomy

Our macroeconomic VAR results are presented in Table 10. These results show that changes in the price of marine fuel had a statistically significant but small impact on real GNP, trade volumes and Irish CPI over the period 1995–2020. Increases in the price of marine fuel typically caused Irish real GNP to fall, with a 1% increase in fuel prices leading to a 0.06% decline in real GNP in the following quarter. Our results suggest that the main channel through which increases in fuel prices affected the economy was through a fall in trade, with growth in trade volumes typically weakening in response to fuel price increases.

The results for real exports and imports show that declines in total trade were primarily driven by lower exports following fuel price increases, with a 1% price increase in fuel prices typically leading to a 0.08% fall in real exports. Perhaps surprisingly, we find that import volumes were largely unaffected by fuel price increases over the period 1995–2020. Although import volumes appear to have been unresponsive, our results provide some evidence that higher fuel costs were passed through to higher prices for imported goods and consumer prices, as reflected in the response of CPI to fuel price increases. Increases in fuel prices were found typically to lead to small increases in the price level, with a 1% increase in marine fuel prices leading to lagged increases in the general price level of 0.02% in the quarter following the increase, 0.01% in the second quarter, and a further 0.01% increase in the third quarter. This suggests that marine fuel price increases were partially passed on to Irish consumers, with consumers generally facing slightly higher prices after an increase in the price of marine fuel.

We present impulse response functions for all our macroeconomic variables in Figure 14. Similar to output and employment in the maritime sector, these impulse response functions show that the impact of a fuel price shock was typically short-lived. In all cases, except for CPI, the impact of a shock to fuel prices died out after around two quarters, with a shock typically causing real GNP and exports to fall in the first and second quarters following a marine fuel price shock. Once again, to forecast the impact of the fuel price increases arising from the Fit for 55 measures, we sum our impulse response coefficients, which are presented in Table 10, to find the long-run impact of a fuel price shock.

Table 10: Macroeconomic VAR results

	Real GNP	Real exports	Real imports	CPI	Consumption	Employ- -ment
Constant	0.01*	0.01	0.01	0.001***	0.01**	0.002
Real fuel price (-1)	-0.06***	-0.08**	-0.05	0.02***	0.001	0.01
Real fuel price (-2)	-0.02	-0.05	0.07	0.01**	0.01	-0.003
Real fuel price (-3)				0.01***		
Real fuel price (-4)				0.001		
R^2	0.32	0.29	0.29	0.64	0.16	0.23
			Impulse responses			
Quarter						
1	-0.06	-0.08	-0.05	0.02	0.001	0.01
2	0.03	-0.03	0.08	0.02	0.01	-0.002
3	-0.01	0.04	0.02	0.02	0.001	0.0003
4	-0.01	-0.01	-0.03	0.001	-0.0009	0.0001
5	0.003	0.001	0.004	0.004	0.001	0.0002

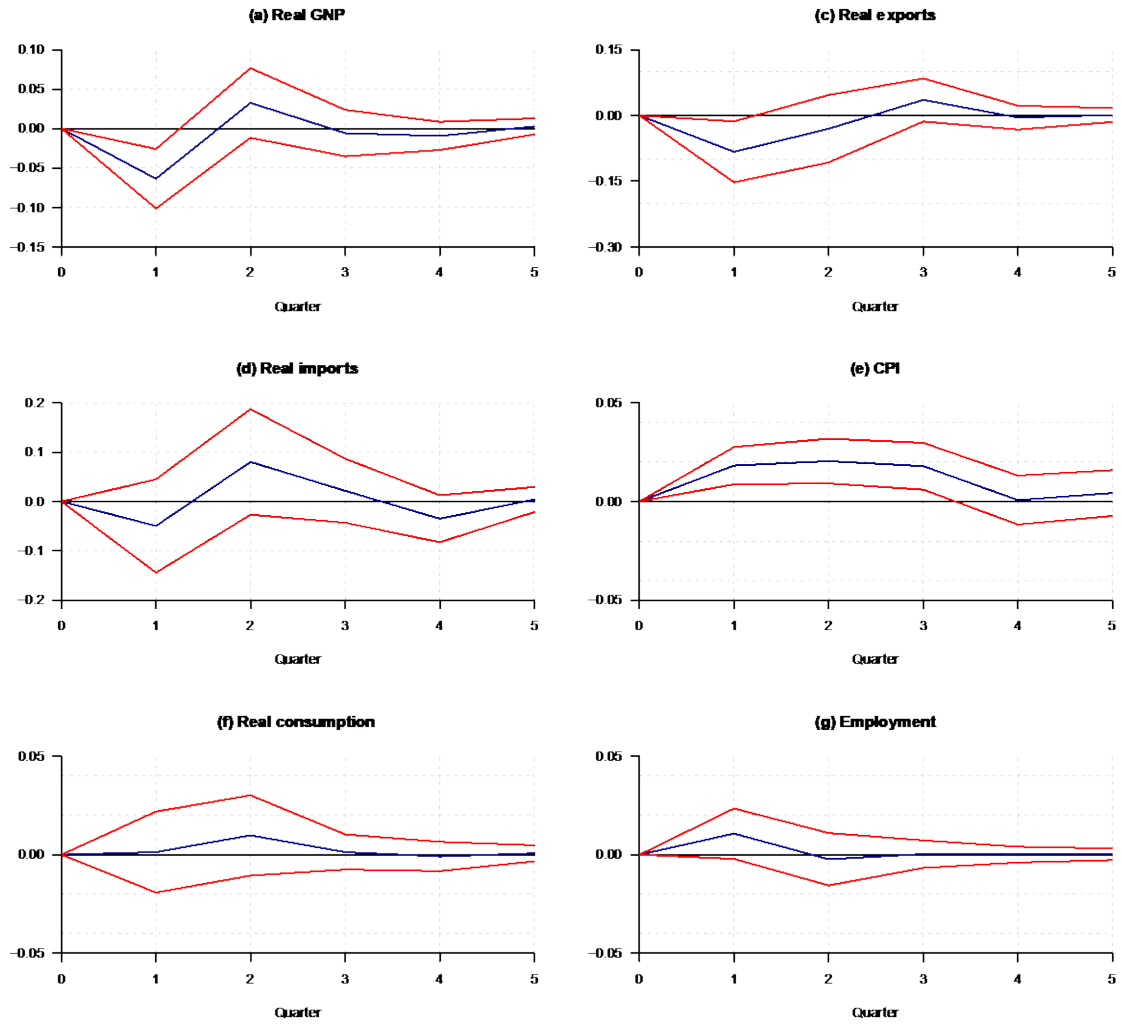

Figure 14: Impulse response functions macroeconomy

The fuel price shocks, shown in Table 5, are the same as those used to forecast the impact of the Fit for 55 measures on the maritime transport sector. Outlined in Table 11, our forecasts indicate that switching to RLFs in the maritime sector will have a modest impact on the overall Irish economy. The impact on real GNP, relative to baseline, is projected to range from -0.09% in 2025 to -1.21% in 2050, with a very gradual increase in the magnitude of the effect over the period to 2050. The projected decline in real exports, compared with the baseline scenario, ranges from -0.17% in 2025 to -2.29% in 2050, and again the decline only grows marginally stronger over the period as the share of RLFs in the maritime fuel mix is gradually increased. The projected impact of these fuel price shocks on imports is statistically insignificant. Although we present projections using the estimated coefficients from our VAR model, fuel price increases are not expected to cause any significant reductions in import volumes. However, as discussed earlier, these fuel price shocks are projected to result in a small increase in the general price level, with the impact ranging from 0.12% in 2025 to 1.83% in 2050, suggesting that higher import prices will be passed through to Irish consumers.

Table 11: VAR macroeconomic projections (from baseline)

	Real GNP	Real exports	Real imports	CPI	Consumption	Employment
2025	-0.09***	-0.17**	0.05	0.13***	0.03	0.02
2030	-0.24***	-0.46**	0.12	0.34***	0.07	0.05
2035	-0.46***	-0.88**	0.23	0.66***	0.13	0.10
2040	-0.71***	-1.36**	0.36	1.02***	0.20	0.15
2045	-1.21***	-2.31**	0.61	1.72***	0.35	0.25
2050	-1.21***	-2.29**	0.61	1.72***	0.35	0.25

7. Conclusions and Discussion

In interpreting the findings of this study, it is worth keeping in mind that the results are expressed as deviations from a so-called "no-policy-change" baseline in which only liquid fossil fuels are used in the maritime fuel mix over coming decades. The Fit for 55 package is projected to increase the price of marine fuel by 28% by 2050 compared with a scenario where the sector continues to rely exclusively on liquid fossil fuels. Our analysis finds that, based on estimated historical relationships, a shock to the cost of maritime fuel of this magnitude is expected to reduce value added in the maritime transport sector by around 7.5% by 2050, relative to the baseline.

It is important to note that these results do not mean that the sector is expected to contract from today's levels of output and value added. Given anticipated continued growth in global trade, Irish trade and the Irish economy over the medium term, Ireland's maritime transport sector will undoubtedly continue to expand over coming decades. Moreover, the effects of the shock to the sector stemming from the new EU policy measures are expected to be spread over many years, given the gradual introduction of these policy changes. These effects will not materialise to any significant degree until after 2035, which should provide the sector with time to adapt to the new policy environment. In addition, it is worth noting that value added in the sector rose 10% annually on average during most of the last decade, in part reflecting recovery from the GFC slump, so the expected loss of value added by 2050 resulting from the Fit for 55 package is roughly equivalent to just a single year's recent growth.

Looking at the broader Irish economy, this study finds that the Fit for 55 package is expected to reduce exports by just over 2% by 2050, relative to baseline. Based on the results of the VAR analysis, we anticipate no effect on imports. The asymmetry we find in the data between the responsiveness of exports and imports to changes in maritime fuel cost is an anomaly that deserves further investigation. Whatever the source of this asymmetry, the overall impact of the Fit for 55 package on Ireland's trade is expected to be small, with even smaller effects on overall economic activity.

Finally, it is illustrative to compare our results with those from other studies that have considered shocks to trade. In their study of the impact of the Fit for 55 package on Ireland's aviation sector, De Bruin and Yakut (2021) consider the potential impact of the Fit for 55 package on Ireland's aviation sector using a computable general equilibrium model. They find that some of the policy proposals in the package could result in a cumulative decrease in aviation value added of between 3% and 14% by

2030. More broadly, Lawless and Morgenroth (2016, 2017) examine the effects on Irish trade of tariff and non-tariff barriers that might arise from Brexit and found that the imposition of these barriers would reduce Irish exports to Great Britain by between 5-8% and Irish imports from Great Britain by between 3-5%. It is clear that Brexit represented a much larger and more immediate threat to Irish trade than the increases in maritime fuel costs likely to result from the Fit for 55 package.

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