UCD GEARY INSTITUTE FOR PUBLIC POLICY DISCUSSION PAPER SERIES

Sectorally Concentrated? The Irish Economy in European Context

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Geary WP2025/03

April 1, 2025

Sectorally Concentrated? The Irish Economy in European Context*

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18 March 2025

Abstract

This paper adds to our understanding of the sectoral interlinkages in the Irish economy and how it relates to the wider EU economy. While the Irish economy is highly concentrated on a GVA basis, it is much less concentrated on the basis of employment and input-output interdependencies. Except for GVA, this level of concentration has not changed much over time. The MNE and domestic sectors each account for close to half of economic output. Their activity is very different but there is still a sizeable interlinkage between them. We also examine the interlinkages of the EU economy. Increasing European strategic autonomy would require greater manufacturing output. Our model suggest that central and eastern member states would benefit most from doing so, relative to their size. Ireland would benefit seventh least. Splitting the Irish economy in two, we find the MNE sector would benefit more than the EU average while the domestic sector is amongst those to benefit least.

Keywords: network analysis, IO tables, macroeconomic measurement, multinational firms, macroeconomic aspects of international trade, globalisation

JEL codes: C45, E01, D57, E01, F23, F4, F62

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*Forthcoming in the Journal of the Statistical and Social Inquiry Society of Ireland. The views expressed in this paper are solely our own and do not necessarily reflect the views of our employers. We thank John FitzGerald; John Flanagan; Michael Flanagan; Dianne Hillery; Ruth Lennon; Stephen McDonagh; Gerard McGuinness; Shaun McLoughlin; Kevin Timoney; Patrick Paul Walsh; seminar participants at SSISI, the CSO and the Department of Finance; and two anonymous referees for very helpful comments on earlier iterations of this work. We thank the SSISI Council for their patience, and Jennifer Currie from Altair for invaluable technical support. All errors are our own.

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1 Introduction

The risks associated with the concentration of the Irish economy in particular sectors is often a source of concern to policymakers. Specifically, a great deal of economic activity is concentrated in a small number of sectors that are dominated by a small number of highly import and export oriented foreign multinational enterprises (MNEs). Furthermore, these concerns have been heightened by growing international hesitancy towards globalisation and the trend towards increasing economies' self-sufficiency. However, the highly globalised nature of the Irish economy makes measuring conventional macroeconomic activity difficult to measure.

This paper uses a large detailed dataset of internationally connected input-output (IO) tables from 2010 to 2022 to add to our understanding of the sectoral interlinkages of the Irish economy and how it relates to the wider EU economy. We first examine the extent to which the Irish economy is concentrated in European context. The Irish economy is highly concentrated on a GVA basis (a measure that has globalisation-related challenges in Ireland) but is not so on the basis of employment and sectors' input-output interdependencies. Over half of Irish GVA is located in two out of Ireland's 20 economic sectors at the NACE A21 aggregation; Manufacturing and ICT, both the highest shares in the EU. Concentration in Administration & support services is also among the highest in the EU. These sectors are so dominant that the GVA allocation is below the EU average for all other sectors.

Examining the same shares using employment shows the economy to be very dispersed, reflecting Ireland's relatively high but evenly spread employment levels in services sectors. The top two sectors (Healthcare, Wholesale & retail) only account for a quarter of employment. However, Ireland has the highest share of employment in ICT in the EU. Public administration & defence was 22nd in the EU while Construction's share of employment was also low in Ireland with a ranking of 21st.

Measured by Irish sectors' interlinkages based on output, intermediate consumption and an iterative algorithm called PageRank (a network analysis tool measuring the relative importance of nodes in a network), the Irish economy also appears relatively dispersed. The top two sectors

(Manufacturing and Professional & scientific activities) made up a third of total Irish output used in Irish intermediate consumption. The two largest consumers of Irish output made up close to half of such consumption. These were Manufacturing and ICT. ICT ranked the highest in the EU for consumption of within-country output.

We create Herfindahl-Hirschman (HH) indices to measure the sectoral concentration of the economy. Comparing Ireland's concentration to other EU countries in 2022, it is the most concentrated for GVA, the second least concentrated for employment and thirteenth for PageRank. Ireland's comparatively low concentration for employment and PageRank is due to its relatively large services sector. By GVA, Ireland's economy has become highly concentrated over time. The opposite is true using employment while with PageRank, concentration has increased but it appears more benign than with GVA.

Ireland has the largest export share of output in the EU. While most of this is exports to outside the EU, Ireland's share of output exported to the EU is also among the highest in Europe (only after the Netherlands and Malta). Ireland supplies more for intermediate consumption than it receives from the rest of the EU in intermediate consumption. Within the EU, the top export destinations for Irish output is Germany, France, Italy, Belgium and the Netherlands. Outside the EU, the largest destinations for Irish output are the US, China and the UK.

We also compare the foreign MNE dominated sectors and the rest in Ireland (referred to as the MNE and domestic sectors throughout the rest of this paper). While producing close to half of overall output each, they are very different. Most foreign MNE output is sent abroad, close to half for final uses and half for intermediate consumption. Most of what is left in Ireland is for intermediate consumption. However, most domestic output remains in Ireland and of what is sent abroad, two thirds is for intermediate consumption. Of what remains in Ireland, a little over half of is for final uses.

The domestic sector consumes much more Irish output than the MNE sector, mostly from itself. However, of the relatively small amount of Irish output that the MNE sector consumes, half of it

is from the domestic sector. The domestic sector consumes just €12 billion of output from the MNE sector while the MNE sector consumes €27 billion from the domestic sector.

We also examine the interlinkages of the EU economy by country and sector in the context of the recent push towards European strategic autonomy. Only 11% of EU intermediate consumption is from outside the EU. Most of the EU's non-EU Industry inputs is from the Manufacturing sector, followed by Distribution, transport, hotels & restaurants. Moving towards increased self-sufficiency would cause increased EU production in these sectors. We use a very simple model that assumes incumbency advantage (where the countries that are already most concentrated in these industries would gain more from such a re-alignment) to estimate the direct impact of substituting non-EU inputs for equivalents from within the EU to examine the effect of doing so.

Our results suggest central and eastern member states would benefit most, relative to their economic size. Ireland would benefit seventh least. Splitting the Irish economy in two, we find the MNE sector would benefit more than the EU average from such a re-allocation while the domestic sector is amongst those to benefit least. We emphasise that these estimates are indicative and do not account for the costs associated with such a re-alignment including those due to price level differences, skills deficits and retraining, regulatory standards, costs for the rest of the economy associated with re-allocation, capital requirements, and challenges associated with sourcing the required intermediate products to produce these intermediates.

The remainder of the paper is structured as follows. Section 2 reviews the broader literature. Section 3 describes the data and the methodology we use with it. Section 4 examines the sectoral concentration of the Irish economy. Section 5 examines the interlinkages between the MNE sector and the domestic sector in Ireland. Section 6 describes the input-output linkages of the EU economy. Section 7 models how on-shoring of EU intermediate consumption could be distributed across EU countries. Finally, Section 8 concludes.

2 Literature review

This paper contributes to several strands of literature. It contributes to the literature on measuring conventional macroeconomic activity in Ireland in the context of its globalised features. This literature goes back a long way.[1] However, its development has accelerated considerably since the 2015 growth rate of the Irish economy, when Irish GDP grew by 26 percent, causing it and many other macroeconomic indicators to come under greater scrutiny. At the centre of this literature is the development of modified Gross National Income (GNI*) and an increasing number of other modified macroeconomic measures that adjust for factor income of large firms that have redomiciled in Ireland through corporate inversions, depreciation on R&D service imports and trade in intellectual property, and depreciation on aircraft leasing.[2] GNI* was recommended by the Economic Statistics Review Group (ESRG) (Central Statistics Office, 2017), which was convened by the Central Statistics Office (CSO) and chaired by the then governor of the Central Bank of Ireland in the wake of the 2015 national accounts results.

Perhaps the most comprehensive paper in this strand of literature to date is Timoney (2023) which constructs a set of bottom up estimates of GNI* based on the income, expenditure and production approaches. He applies the corresponding modified components of these measures to analyse the economy through institutional sector accounts and the growth accounting productivity framework. Timoney provides estimates of the modified labour share, modified productivity, the modified savings rate, output* and intermediate consumption*. He finds that productivity on a GNI* basis is more rapid that analysis of the domestic sector would imply and that two fifths of modified capital formation is by the MNE sector.

Timoney (2023) is careful to trace many of the antecedents in the literature, including FitzGerald (2013) (which adjusts GNP for redomiciled firms in Ireland), Lennon (2022) (which breaks GNI*

[1] See, for example, Kennedy (2001).

[2] These are typically referred to with the prefix “modified” or with an asterisk at the end, e.g. Galstyan (2018) creates an estimate of the modified net international investment position or net IIP*.

growth down by income and expenditure) and several papers in response to the 2015 results; FitzGerald (2016), Honohan (2016), Lane (2017) and Conolly (2017).

An alternative approach to using GNI* and its associated modified measures is to instead focus on foreign MNE and domestic (also known as indigenous) firms in Ireland separately. O'Grady (2024) is closest to our analysis in this respect. O'Grady derives separate IO tables for these two components of the economy in 2019 to examine the integration of MNEs within the Irish value chain. The paper finds evidence consistent with positive FDI spillovers, where domestic firms experience productivity gains through interactions with MNEs. O'Grady derives his tables using a combination of the CSO Supply and Use Tables, the Eurostat Annual Enterprise Statistics, and the Eurostat Foreign Control of Enterprises dataset to make more precise and recent estimates of these groupings.

Splitting the macroeconomy by foreign MNE and domestic and examining the interactions between them meshes with the microeconometric literature on FDI spillovers. The literature on the interconnections between foreign MNEs and domestic firms in Ireland is characterised by a mix of positive, negative and non-significant FDI spillover results. Barrios et al. (2011) and Di Ubaldo et al. (2018) also use IO tables to estimate spillovers via supplier and buyer relationships between domestic firms and foreign MNEs, although in combination with microdata. Haller et al. (2023), Flaherty (2024a) and Flaherty (2024b) are more recent MNE spillover analyses based on labour mobility.

This paper uses a network analysis tool called PageRank to examine how important each sector is to the overall flow of intermediate inputs between sectors in an economy. There are several antecedents to this. Cerina et al. (2015) apply PageRank and eigenvector analysis to the World Input-Output Database (WIOD) dataset to show how the world economy has much more input-output interlinkages in 2011 relative to 1995. They find the PageRank approach to be more useful than the eigenvector method.

Blochl et al. (2011) applies network analysis methodology to each economy in the OECD. They use random walk centrality and counting betweenness to isolate the most central sectors in each

economy. Cahen-Fourot et al. (2021) also employ the WIOD dataset to examine the effect of decarbonisation-related capital stranding on economies.

O'Clery (2016) uses network analysis to examine sectoral concentration in the Irish economy, applying it to trade export data from 1995 to 2013. Irish exports are less diversified than similarly advanced countries and concentrated in two clusters of product codes; the pharmaceutical and electronics cluster (predominantly foreign MNE firms) and the agri-food cluster (predominantly domestic producers). O'Clery suggests that this reduces the possibility of spillovers to domestic firms and cautions that a high level of product concentration exposes the economy to industry shocks.

Landman et al. (2022) also measure relatedness between industries in Ireland, based on worker mobility. They find that domestic industries are both more likely to enter and less likely to leave a region if they are related to industries containing both domestic and MNE firms. Domestic firms are less likely to enter or survive in industries that are almost mostly made up of MNEs.

Network analysis is used in an increasingly wide variety of settings. For example, Hynes et al. (2023) intuitively apply network analysis to international beer styles. While almost all beer styles have only a small number of key ingredients, some styles are more resilient than others due to readily available substitute ingredients in their region.

3 Data

3.1 Data sources

Our first data source is Eurostat's FIGARO input-output (IO) dataset, broken down by industrial sector. This data source allows us to analyse the structure and interconnectedness of the EU economy by sector and member state, as well as its connection to external countries. It also allows us to create a measure of countries' sectoral concentration based on network linkages.

The FIGARO dataset has several strengths for analysis. Unlike the IO tables produced by member states, it is annual, rather than (in many cases, including Ireland) quinquennial (at five year

intervals). It is also more timely, with the latest data available for 2022. The data are also symmetric and detailed, whereby each sector is at the NACE A64 aggregation and the same sectoral breakdowns of the data can be compared across all EU countries.[3] Furthermore, the tables are internationally linked, allowing us to see input-output linkages between different EU and non-EU countries (Eurostat, 2021).[4] Another benefit is that the FIGARO data are broken down by industrial sector, rather than product.[5]

The FIGARO data are estimated using annual national accounts variables, supply and use tables, IO tables, international trade data, international services trade data and business statistics. These estimates are often balanced across different sources due to inconsistencies and asymmetries. Where data are unavailable for some countries, estimates are made using data from others. The data for the latest two years available (2021 and 2022 at the time of writing) are projections based on the latest data. Confidential national data are anonymised in the compilation process (Remond-Tiedrez and Rueda-Cantuche, 2019).[6]

While the FIGARO data are compiled with reference to a large variety of data sources, the strengths of their specific components should be treated with caution. Producing supply and use tables (the core source data for IO tables) involves many assumptions and only results in an approximation of the product and industry interactions in the economy. Input-output data require many additional assumptions, generating further imprecision. The extent of the assumptions required increases still further when creating internationally linked IO tables.

Our second data source is the Eurostat national accounts main aggregates. We obtain data on GVA, output and employment by member state at the NACE A21 and A64 sector level. At the

[3] NACE Rev.2 is the standard classification of industrial activity in the EU. NACE A64 is a grouping of these classifications into 64 activities. NACE A21 is a grouping of these into 21 sectors. We apply our analysis at both levels of aggregation. See Eurostat (2013) for more information on the different NACE aggregations available.

[4] The data contains direct linkages with the EU's 18 main trading partners and a single grouping for the rest of the world. These 18 trading partners are Argentina, Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Norway, Russia, Saudi Arabia, South Africa, South Korea, Switzerland, Türkiye, the UK and the US.

[5] The FIGARO data are also available product to product. Domestic data are often available only on one basis. For example, the CSO data for Ireland is only available on a product to product basis.

[6] For further discussion on the FIGARO tables, see Rueda-Cantuche et al. (2018) and Valderas-Jaramillo et al. (2019). See O'Grady (2024) for discussion on Ireland's IO tables produced by the CSO.

member state level, we obtain GDP, import and export data. We also obtain Eurostat data on member states' land area. Where countries have missing sectoral GVA and output data at the A64 level due to confidentiality constraints, we impute these values. As there are no missings at the A21 level in the Eurostat database, we aggregate the A64 data to the A21 level and subtract them from the full A21 values to calculate residual GVA and output values. We then apportion these out using A64 employment shares of these residual groups of sectors.[7] This approach understates sectoral concentration in Ireland as sectoral GVA and output for these missing cells are more concentrated than employment values.

3.2 Data preparation for IO-based measure of sectoral concentration

We create within-country sector-to-sector input-output networks for all 46 countries for each of the years 2010-2022. Each of these networks reflects the flow of intermediate goods and services between all of the sectors of the economy (excluding NACE sector U, Activities of Extraterritorial Organisations). We also filter out interactions with final uses: final consumption expenditure (of general government, households, and non-profit institutions serving households), gross fixed capital formation, and changes in inventories and acquisition less disposals of valuables. This leaves us with sectors interacting with each other on the basis of output and intermediate consumption. We do this at both the NACE A21 and the A64 level. These networks estimate the domestic flow of intermediate inputs within each country's economy.[8]

The dataset is an adjacency matrix, where each sector appears in both the rows and the columns (20 sectors at A21 and 63 sectors at A64, as sector U is excluded). In the input-output network, nodes are sectors, and edges are the value of the intermediate goods and services exchanged between those sectors. The networks are therefore both directed and weighted, with the direction of each edge indicating the direction of the flow of intermediate inputs and the edge weight indicating the value of those inputs. The networks also contain self-loops, which reflect the flow

[7] A64 employment data has no missings.

[8] For some of our analysis, we also keep the interactions across countries, or different aggregates, such as the EU as a whole.

of intermediate inputs between firms within a sector. Including self-loops means that we take account of the importance of a sector to itself.[9]

The networks can be represented algebraically as:

$$IO_{c,t} = \begin{bmatrix} S_{1,1} & \dots & S_{1,n} \\ \vdots & \ddots & \vdots \\ S_{n,1} & \cdots & S_{n,n} \end{bmatrix}$$

Where $IO_{c,t}$ is the sector-to-sector input-output network for country c for year t, and $s_{i,j}$ is the value of the intermediate inputs exchanged from sector i to sector j, where $i, j = 1, \dots, n$.

3.2.1 Using PageRank to measure sectors' importance

PageRank (Page et al., 1999) is a centrality measure for assessing the relative importance of nodes in a directed network. PageRank is an iterative algorithm measuring the relative importance of nodes in a network. PageRank centrality considers a node to be important if it is well-connected to other important nodes. PageRank centrality captures how important each sector is to the overall flow of intermediate inputs between sectors in an economy. The original PageRank centrality measure is not appropriate for sector-to-sector input-output networks, as the edges for the networks are both weighted and directed. We follow Cerina et al. (2015) in using the weighted version of PageRank instead.

Applying this weighted PageRank algorithm to the networks assigns a value $p_i \in (1,1)$ to each sector in the network, with $\sum_{i=1}^{n} p_i = 1$. The PageRank centrality of each sector can be interpreted as the share of the overall network importance of sectors in the economy.

[9] This approach is consistent with Blochl et al. (2011) and Cerina et al. (2015) but differs from Cahen-Fourot et al. (2021).

3.2.2 Using the Herfindahl-Hirschman Index as a measure of sectors' concentration

We use the Herfindahl–Hirschman (HH) index to measure the concentration of an economy. The HH index is usually used to measure the concentration of a market.[10] The HH index increases both as the number of firms in the market decreases and as the difference in size between those firms increases. Here we base it on sectors' shares of the economy using Gross Value Added (GVA), employment and relative PageRank centrality. As far as we know, we are the first to use a HH index in this context. The HH index of an economy with *n* sectors is given by:

$$HH\ index = \sum_{i=1}^{n} {s_i}^2$$

where $s_i$refers to the percentage share of sector i in the overall economy, $\sum_{i=1}^{n} s_i = 1$

In our context, n is always the same across economies and over time.

The weighted PageRank HH index of a sector is given by:

$$HH\ index_{PageRank} = \sum_{i=1}^{n} {p_i}^2$$

where s_i refers to the weighted PageRank of sector i in its input-output network, $\sum_{i=1}^{n} p_i = 1$.

4 Sectoral concentration in Ireland relative to the EU

First, we examine the composition of the Irish economy by sector at the A21 level using several different measures, and compare this to other EU countries. The first two are GVA shares and employment shares. We also use sectors' shares based on output for intermediate consumption, intermediate consumption for output and PageRank. We use data for 2022, the latest year for which there is FIGARO data available.

[10] See, for instance, Devereux and Studnicka (2024).

Figure 1: GVA shares by sector

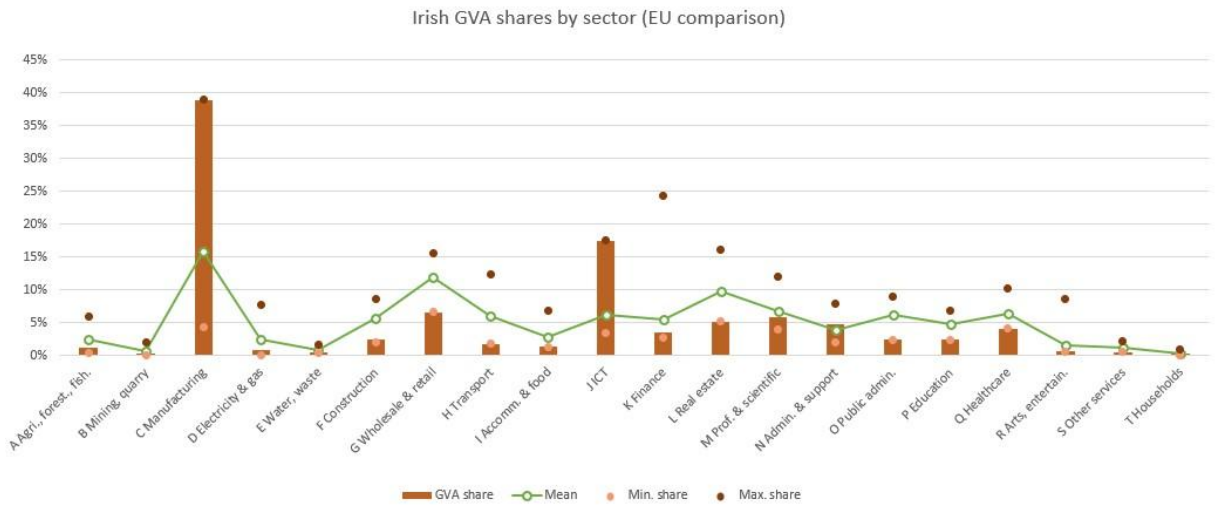


Figure 1 shows Irish GVA shares at the A21 level in EU context in 2022. The high degree of concentration reflects the globalised nature of the Irish economy and is driven by the activity that GNI* is designed to adjust for, namely factor income of large foreign MNEs, depreciation on R&D service imports and trade in intellectual property, and depreciation on aircraft leasing. Over half of Irish GVA (57%) is located in two economic sectors; Manufacturing and ICT. This reflects a large degree of economic activity in chemicals, pharmaceuticals, medical devices and ICT-related goods and services. The largest Irish economic sector is Manufacturing, worth 39%. This is the highest share in the EU, 23 percentage points above the EU average for Manufacturing of 16%. Ireland also has the highest sectoral share of ICT of (17%), compared to an EU average of 6%. Irish concentration in Admin & Support Services is also among the highest in the EU (sixth), at 5%, one percentage point above the EU average of 4%. These sectors are so dominant that the GVA allocation is below the EU average for all other sectors. Even Finance (Dublin placed 14th on the Global Financial Centres Index for 2024) is below EU average (ranked 23rd in the EU). Seven of Ireland's economic sectors rank last in the EU: Water & waste, Wholesale & retail, Transport, Real estate, Public administration & defence, Education, Healthcare, and Other services.

Figure 2: Employment shares by sector

Examining the same shares using employment in 2022 provides a very different picture (Figure 2). Ireland's comparatively large employment in the services sector suggests that the economy is very dispersed. The top two sectors (Healthcare, Wholesale & retail) only account for 26% of employment. Using this measure, Manufacturing is well below the EU average. Manufacturing employs only 11% of Irish employment, well below the EU average of 14% and ranking it 17th in the EU. However, at 6.5%, Ireland has the highest share of employment in ICT in the EU. No other sectors come close to the EU maximum shares. Nevertheless, several other sectors have employment shares above the EU average. Ireland's Finance share is 6.5% (fourth in the EU), Education is 8.3% (fifth), Accommodation & food is 7% (seventh) and Healthcare is 13% (eighth). The sectors ranked the lowest in EU comparison were Real estate (0.5%, with a ranking of 26st), Transport (4.4%, with a ranking of 24th) and Wholesale & Retail (12%, with a ranking of 23rd). Public administration & defence was at 5.3% (22nd in the EU) while Construction's share of employment was also low in Ireland at 6.5%, ranking it 21st.

Figure 3: Sectors' shares of output for use in Irish intermediate consumption

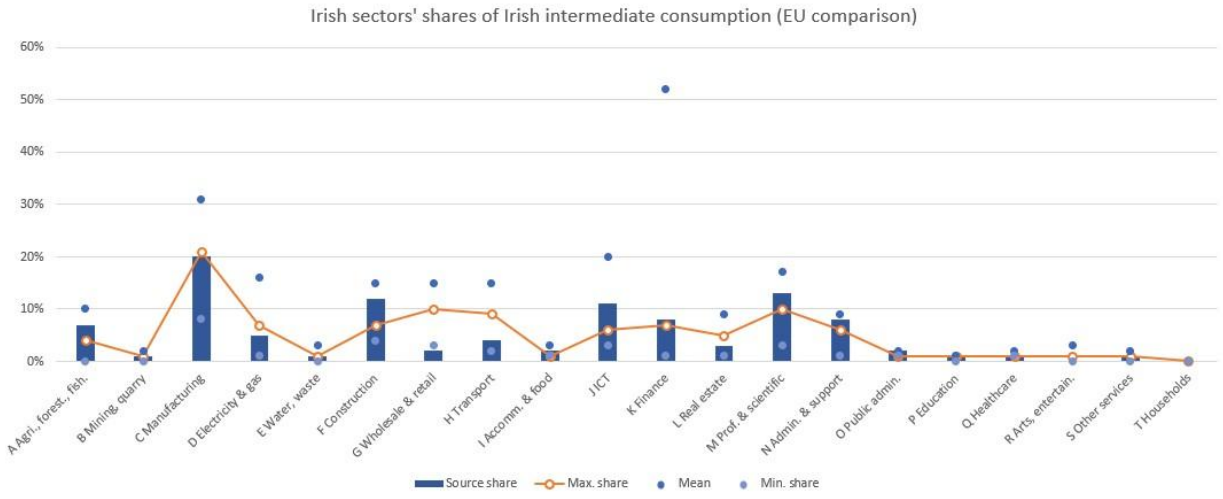


Figure 3 shows sectors' shares of output for use in Irish intermediate consumption. Using this measure, the Irish economy appears relatively dispersed. The top two sectors (Manufacturing and Professional & scientific activities) made up 32% of total Irish output used in Irish intermediate consumption. There were no cases in Ireland where a sector's share of output for the country's intermediate consumption was highest in the EU. Nonetheless, ICT was second in the EU (11% relative to an EU mean of 6.2%) and in third place for Construction (12% relative to an EU average of 7.5%). Public administration occupied fourth place (2.2% relative to the EU average of 1.2%). Two sectors had the lowest share of output for within-country intermediate consumption in the EU. These were Wholesale & retail (1.8% versus the EU average of 9.7%) and Real estate (2.5% versus the EU average of 4.8%).

Figure 4 shows sectors' shares of Irish consumption of Irish output. The two largest consumers of Irish output made up 42% of such consumption. These were Manufacturing and ICT (27% and 15% respectively). ICT ranked the highest in the EU for consumption of within-country output. This suggests that the ICT sector is very integrated with the Irish economy, although much of this is interaction occurs within the ICT sector. Other sectors ranked second (1.6% versus an EU mean of 0.9%) while Finance ranked third (9.9% versus 5.6%). Several sectors ranked the second lowest for consumption of within-country output: Electricity & gas (1.5% versus an EU mean of 4.9%), Water,

waste (0.6% compared to 1.2%), Wholesale & retail (5.2% versus 9.6%), Transport (5.3% versus 8.1%), Arts & entertainment (0.6% versus 1.9%).

Figure 4: Sectors' shares of Irish consumption of Irish output

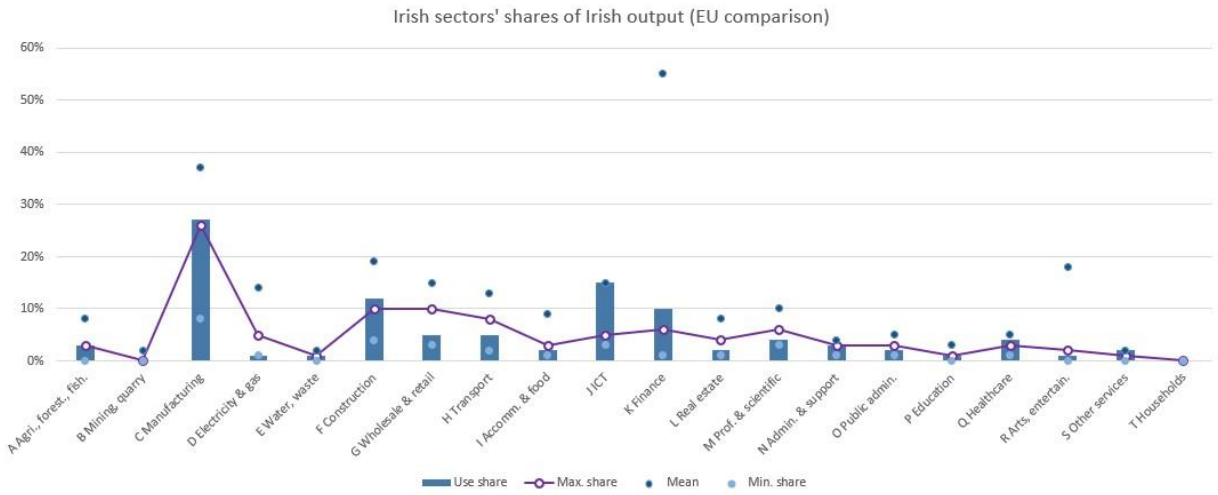
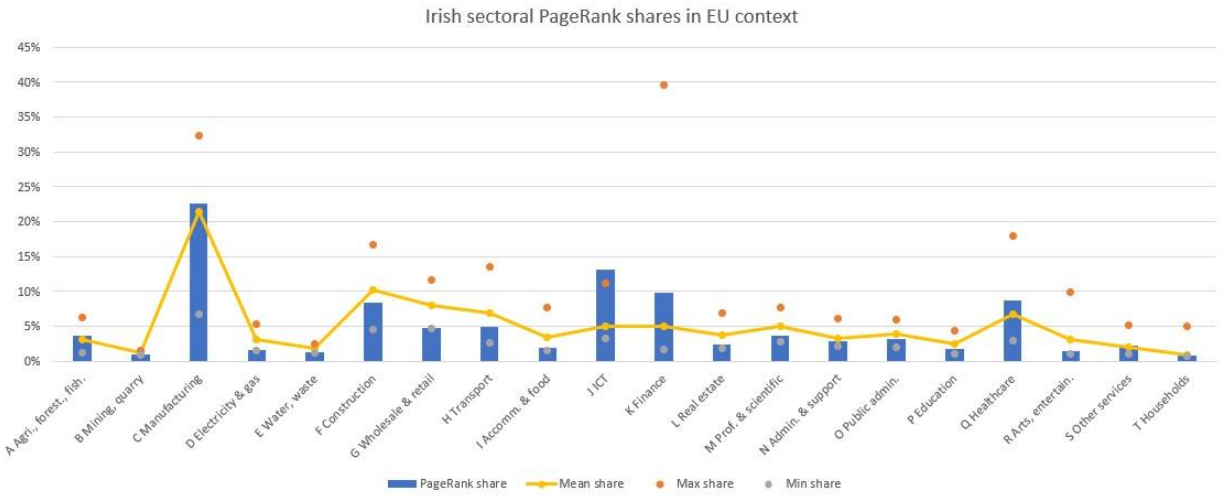


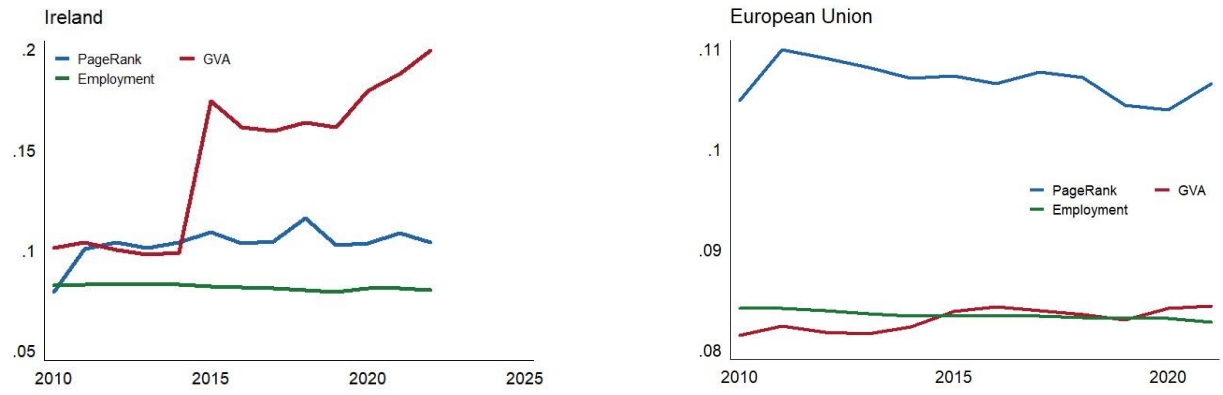
Figure 5 refers to PageRank shares by sector. PageRank centrality captures how important a sector is, based on input-output linkages within an economy. PageRank centrality considers a sector to be important if it is well-connected to other important sectors. As we include self-loops, this measure also takes account of the importance of a sector's input-output linkages with itself. Here the most important sectors are Manufacturing and ICT, making up a combined 33% of the economy. Manufacturing is at 23%, slightly above the EU average of 21%, with a ranking of 12th. At 11%, ICT in Ireland is ranked first in the EU in terms of its country importance. Finance ranks third, Healthcare fourth, Other sectors fourth. Arts & entertainment ranks 27th in the EU. Wholesale & retail ranks 26th in the EU, as does Real estate, and Professional & scientific activities.

Figure 5: PageRank shares by sector



4.0.1 Ireland's economic concentration using HH index

Figure 6: Sectoral concentration over time (A21)



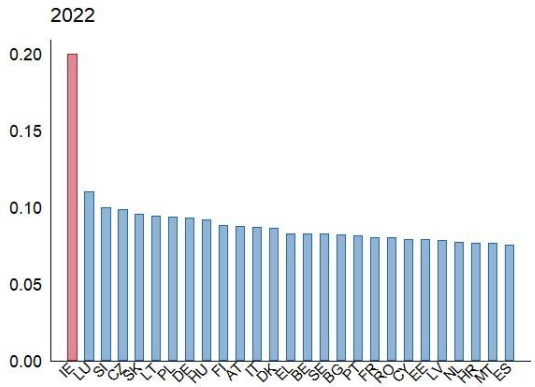
(a) Ireland

(b) European Union

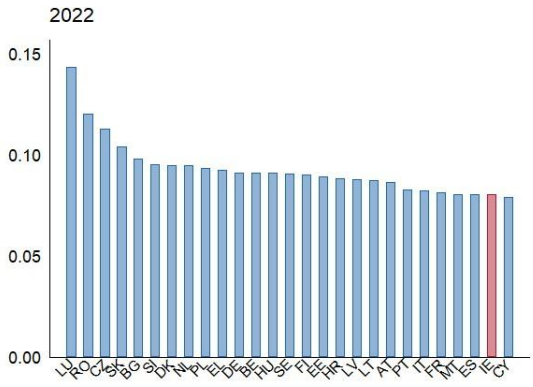
We create HH indices to measure the sectoral concentration of the economy. According to these indices, the more economic activity is evenly spread across sectors, the lower the concentration of the economy. This indicator therefore highlights instances of high levels of sectoral concentration. However, it is much less applicable in prescribing what a diversified economy should like (the most diversified 20 sector economy is where each sector's share is 5%). The NACE

classification system is designed to categorise different types of economic activity, not to create groupings into which the economy should be evenly distributed.

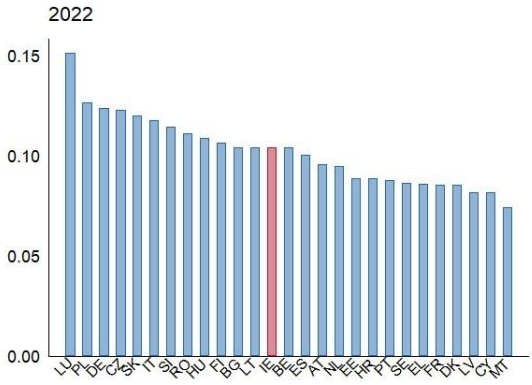
Figure 7: Sectoral concentration using HH indices: Ireland in EU context (A21)



(a) GVA



(b) Employment



(c) PageRank

Figure 6 shows Ireland's sectoral concentration over time under the three measures. The index for Employment remains stable throughout, declining slightly. This decline is associated with increased employment in the services sector. Similarly, the index for PageRank increases in 2011 and remains steady for the remaining years. However, the index for GVA concentration increases 2015 (associated with the level shift in the size of the economy in that year). The chart to the right shows concentration for the EU overall. PageRank and GVA are stable at close to 8%.

Figure 25 (Appendix) shows the equivalent chart based on the A64 composition of the economy. Here there is no evidence of the Irish growth rate in 2015. This reflects how Ireland's GVA for the A64 sectors omitted for confidentiality is more concentrated than employment values.

In Figure 7, we show Ireland's concentration using the HH index in EU context in 2022. Ireland is the most concentrated for GVA, the second least concentrated for employment and thirteenth for PageRank. Using the index at A64, the ranking is less stark. Ireland ranks third for GVA, thirteenth for employment and tenth for PageRank (Figure 26, Appendix).

Figure 27 shows the change in Ireland's ranking between 2010 and 2022 at A21 level. Ireland moved from fourth to first for GVA, was most diversified by employment throughout and moved from below average to above average under the PageRank measure.

4.0.2 Ireland's interlinkage with the EU

Ireland has the largest export share of output in the EU. Most of this exported to outside the EU but given its share value, Ireland's share of output exported to the EU is also among the highest in the EU. Ireland is more important to the EU as a supplier than a buyer. Ireland supplies more for intermediate consumption than it receives from the rest of the EU in intermediate consumption.

Irish output was €935 billion in 2022. Of this, €210 billion was consumed in Ireland, €234 went to the rest of the EU while €320 billion was sold to the rest of the world (Figure 22, Appendix). Within the EU, the top export destinations for Irish output is Germany, France, Italy, Belgium and the Netherlands (Figure 23, Appendix). Outside the EU, the largest destinations for Irish output are the US, China and the UK (Figure 24, Appendix). The second largest category is Other, indicating that (except for the US, China and the UK) some of Ireland's largest export destinations are different to the top 15 export destinations for the EU.

Figure 29 (Appendix) shows that Ireland's share of output to the rest of EU is the third highest in the EU after the Netherlands and Malta (Figure 30, Appendix). Figure 28 (Appendix) shows the rest of EU's intermediate consumption of a country's output as a share of a country's intermediate

consumption of the rest of the EU. Ireland supplies supply 31% more intermediate consumption to the EU than what it consumes in intermediate consumption from the EU.

5 Interlinkages between the foreign MNE and the domestic sector in Ireland

Figure 8 refers to Irish GVA split by MNE and domestic. The MNE sector makes up most of the Irish economy in 2022 (53% or €261 billion in 2022). Most of this is in Industry (€113 billion) and ICT (€95 billion), with the remainder in Professional, administrative & support activities.

Figure 9 shows the economy split by employment in 2022. The MNE sector employs 353 thousand workers, or 13% of employment (total employment was 2.684 million). The largest part of the MNE sector is ICT (175 thousand workers), followed by industry (166 thousand). The remaining 12 thousand in the MNE sector are located in Professional, administrative & support activities.

Figure 8: Irish GVA by MNE and domestic (A10)

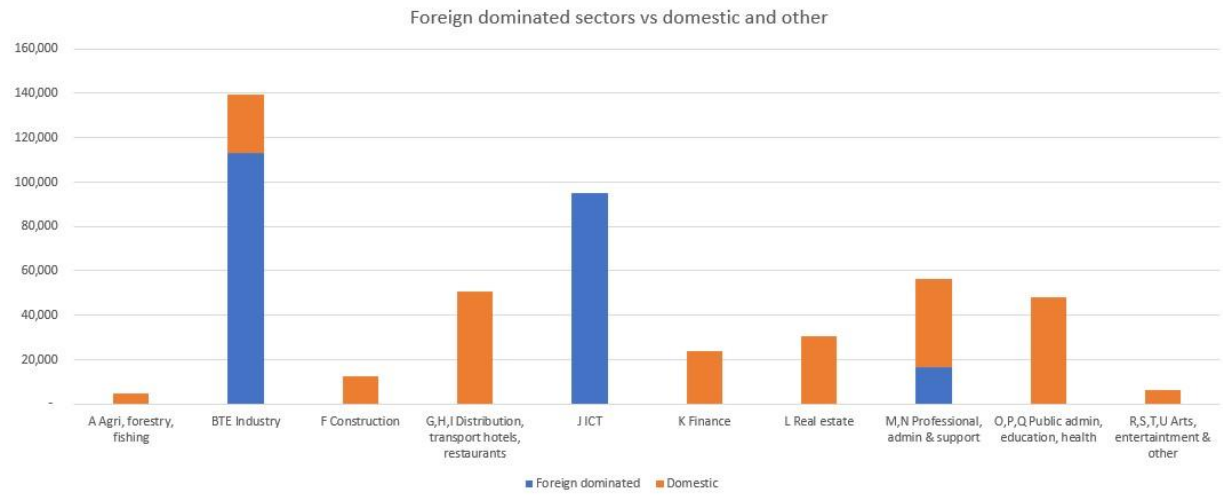
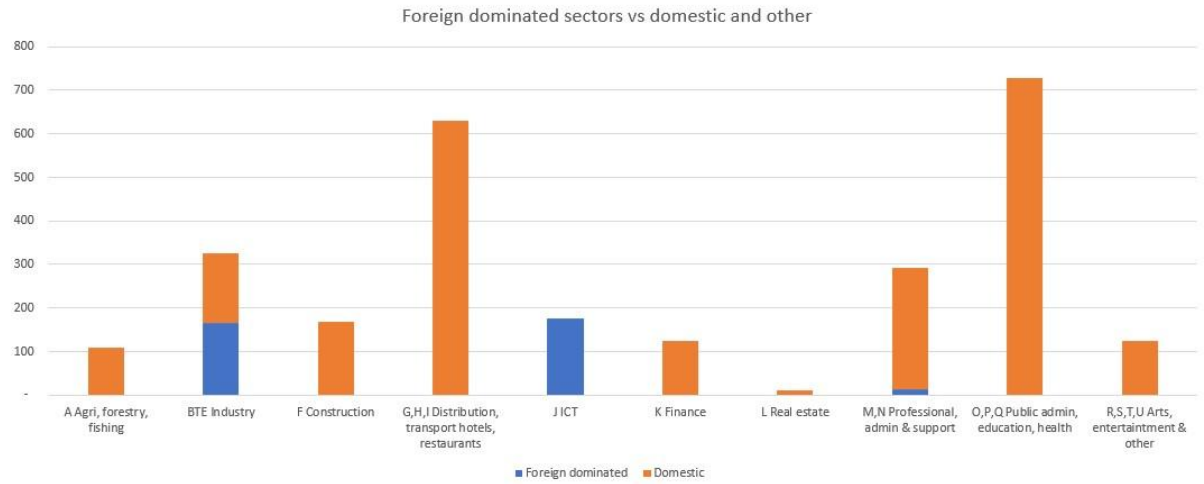


Figure 9: Irish employment by MNE and domestic (A10)



These MNE and domestic sector groupings follows work by the CSO.[11] The values for the MNE sector should be largely seen as a lower threshold of the extent of foreign MNE concentration in the Irish economy. For example, employment in the MNE sector is considerably lower than overall foreign MNE employment in the economy, making up only a little more than half (56%) of the total 623 thousand workers in foreign MNEs.[12]

The difference between the MNE sector's GVA and the GVA of foreign MNEs in the economy may also be very stark. Most of the output of the Food & drink sector is made by foreign MNEs, as is the case for the Financial sector. Timoney (2023) notes that the domestic sector includes aircraft leasing firms.[13] While often Irish led, these are largely foreign owned and among the most strongly affected by globalisation. Foreign MNEs are also present across the rest of the economy (often

[11] The CSO *Output and Value Added by Activity 2023* publication defines these sectors as NACE 19, 20, 21, 26, 31-32, 58, 61 and 62-63. Ideally, this split would be made at the firm level, or potentially even by the percentage share of firm ownership.

[12] This higher value is from the CSO's Structural Business Statistics, which is calculated at the firm level. Structural Business Statistics covers sectors B to S (excluding O Public administration & defence and S94 Activities of membership organisations), and therefore does not cover all MNE entities either, meaning that the actual number of employees employed in foreign MNEs is even greater than this.

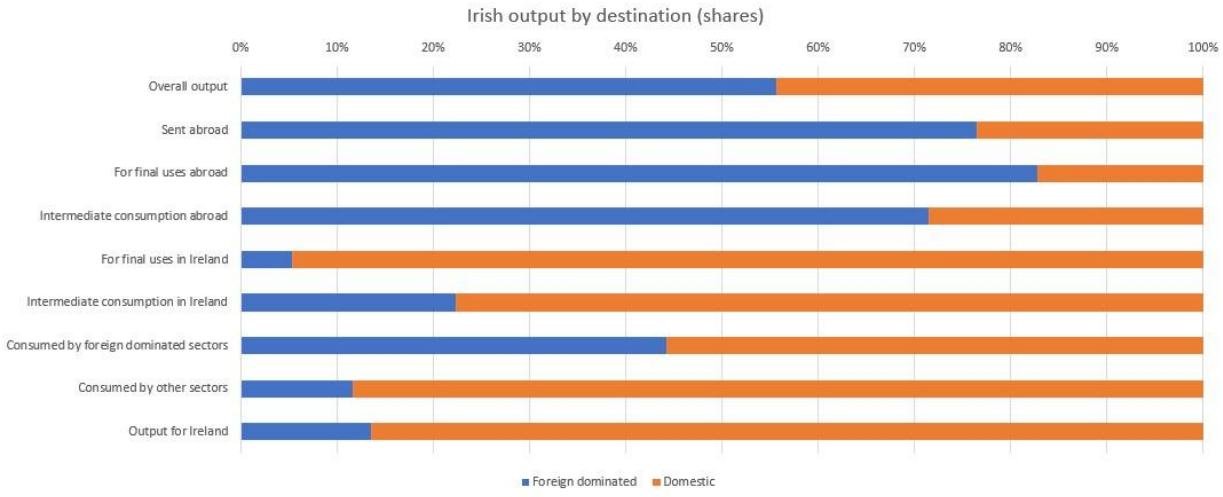
[13] Timoney's focus is primarily from a GNI* type framework, noting that the domestic sector grouping leaves out wages earned in some of the most productive parts of the economy, while continuing to include the gross operating surplus of some of the most globalised.

with a considerable market share) including in Agriculture, Construction, Wholesale, Retail, Real estate and Professional, scientific & technical activities.

Nonetheless, this measure allows us a relatively straightforward and intuitive grouping of the two main components of the economy. There have been also been attempts to further refine the split (e.g. O'Grady (2024) and Timoney (2023)) to better understand indigenous activity. While there is much merit in this, making such adjustments without the microdata is also imprecise and judgement-based, particularly with the additional interactions in our data. For simplicity, we follow the NACE-based breakdown.

While producing almost half of overall output each, the two components of the economy are very different. Figure 10 shows each component by share. The MNE sector produce 56% of overall output, 77% of output sent abroad, 85% of output for final uses abroad, and 72% of output for intermediate consumption abroad. As for output used Ireland, foreign MNEs produce 5% of final uses, 22% of intermediate consumption. Of intermediate consumption produced and consumed in Ireland, foreign MNEs consume 44% of that produced by foreign MNEs, and 12% of that consumed by other sectors.

Figure 10: Irish output by MNE and domestic (shares)



The domestic sector produce 44% of overall output, 33% of output of output sent abroad, 25% of output for final uses abroad and 72% of Irish output for intermediate consumption abroad. In summary, the MNE sector overwhelmingly exports abroad and exports most of both final and intermediate products that are exported. The MNE sector produces only 5% of output for final uses and 22% for intermediate consumption in Ireland. It is clear also that what it does produce for consumption in Ireland, it is mostly for the MNE sector (65%). Of Irish output consumed by the domestic sector, 88% is made by the domestic sector.

Figure 11 shows that of overall output of €936 billion, 521 (56%) was by the MNE sector, with the remaining 415 billion from other sectors. Most (626 billion, or 67%) of this output was sent abroad, with the MNE sector making up 77% of this. Of the output sent abroad, most (€349 billion) was for intermediate consumption. Of the €309 billion output used in Ireland €159 billion (or 17%) was in final uses, with the remaining €150 billion in intermediate consumption. The MNE sector consumed just €49 billion of Irish output, while other sectors consumed €101 billion of it.

Figure 11: Irish output by MNE and domestic sector and destination

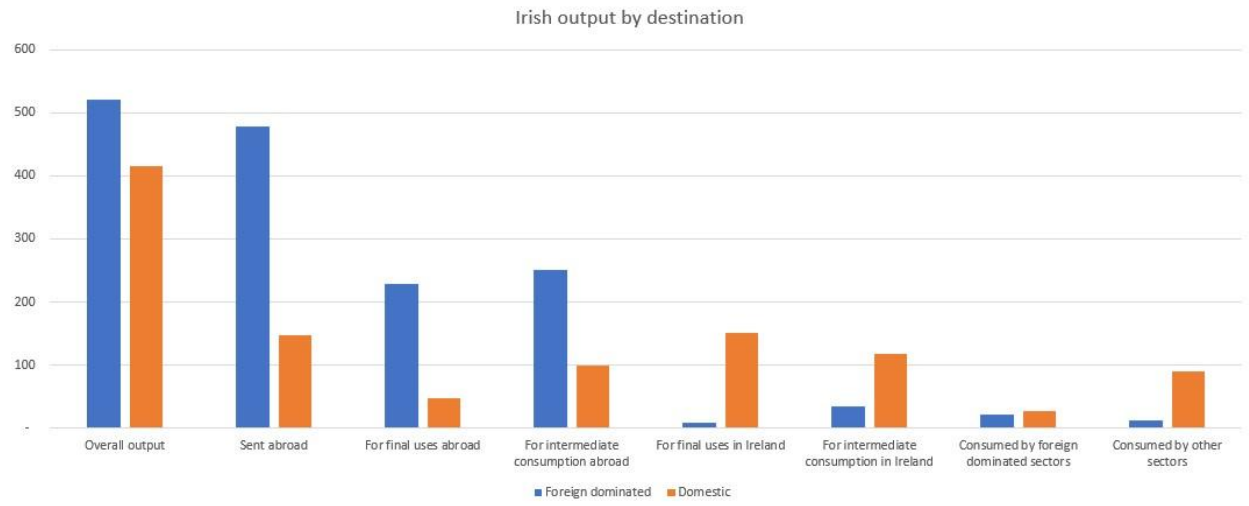


Table 1 presents the above two figures in tabular form. Most foreign MNE and domestic output is for intermediate consumption. Most foreign MNE output is sent abroad (€479 billion out of a total of €521 billion), close to half (48% or 229 billion) for final uses and half (52% or €250 billion) for

intermediate consumption. Of the €43 billion that remains in Ireland, €34 billion (79%) is for intermediate consumption.

However, most domestic output remains in Ireland, with 35% (€147 billion out of €415 billion) sent abroad. Of what is sent abroad, two thirds (€99 billion) is for intermediate consumption. Of what remains in Ireland, a little over half of it (36% or €151 billion) is for final uses.

As for the interaction between the sectors, the domestic sector consumes €101 billion of Irish output while the MNE sector consumes €49 billion. The domestic sector consumers just €12 billion of output from the MNE sector and €89 billion from itself. On the other hand, the MNE sector consumes €27 billion of domestic outputs and €22 billion of outputs from the MNE sector.

While most MNE output is not for the domestic market, there remains considerable interlinkages between foreign and domestic. Nonetheless, the extent of which this is genuinely between domestic and foreign firms is not clear. As we have seen neither the MNE or the domestic sector are exclusively MNE or domestic.

6 The input linkages of the EU economy

This section describes the input linkages of the EU economy. Table 2 (Appendix) shows the composition of the EU economy by country. By GDP share, the largest five economies (Germany, France, Italy, Spain and the Netherlands) account for nearly three quarters (70%) of the 16.1 trillion EU economy. In terms of its 447 million population, the top five (Germany, France, Italy, Spain and Poland) account for two thirds (67%). For exports, the five largest (Germany, France, the Netherlands) make up 69% of the 8.9 trillion total. For land area, the largest five (France, Spain, Sweden, Germany and Finland) make up 53% of the 4.1 million square kilometre total.

As a small country with a highly globalised economy, Ireland occupies different shares and ranks on these measures. It terms of the more globalised measures, Ireland places relatively highly with exports of 8% (4th), imports of 5.8% (7th) and GDP of 3% (9th). However, by more grounded indicators, Ireland places further down the list, making up 1.6% of the economy under GNI* (13th), 1.7% of land area (15th), and 1.1% of the population (19th).

Figure 12 refers to output split by GVA and intermediate consumption. Total EU output in 2022 is 31.6 billion. The largest share is industry at 10.1 billion (32%). Europe's second largest source of output is Distribution, transport and hospitality at €5.8 billion (19%). This includes Wholesale & retail, transport, and hotels & restaurants. The third largest category is Public administration, education & health (€3.8 billion or 12%). Figure 12 also shows the considerable heterogeneity in the composition of intermediate consumption in the economy. Intermediate consumption in manufacturing is €7.1 billion, or 70% of output. Construction is next, with an intermediate consumption share of 64%. A higher intermediate consumption intensity of output indicates a greater vulnerability to price changes. If producers cannot pass on price changes, a large increase in intermediate prices will cause a much larger decline in GVA. Finance has the lowest share of intermediate consumption (23%), followed by Public admin, education and health (29%).

Figure 12: EU output by sector

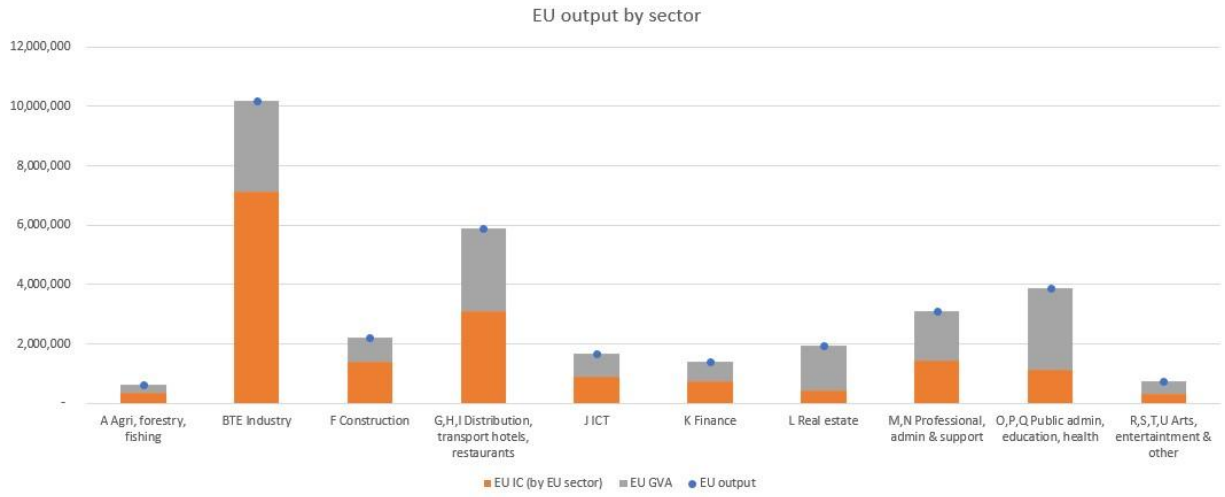


Figure 13 refers to intermediate consumption in the EU by EU and non-EU source. Inputs from outside the EU make up €2.1 billion or 11% of EU intermediate consumption. Most non-EU intermediate inputs were used by Industry (1.2 billion, making up 17% of Industry intermediate

consumption and 7% of all EU intermediate consumption). The second largest consumer of non-EU intermediates was Distribution, transport hotels, restaurants (€307 billion, or 2% of overall intermediate consumption). ICT had a large share of intermediate consumption from outside the EU (17%) but it was relatively small in value (€150 billion). Real estate had the lowest non-EU share (3% of intermediate consumption, or €14 billion).

Figure 13: EU intermediate consumption by sector and EU and non-EU source

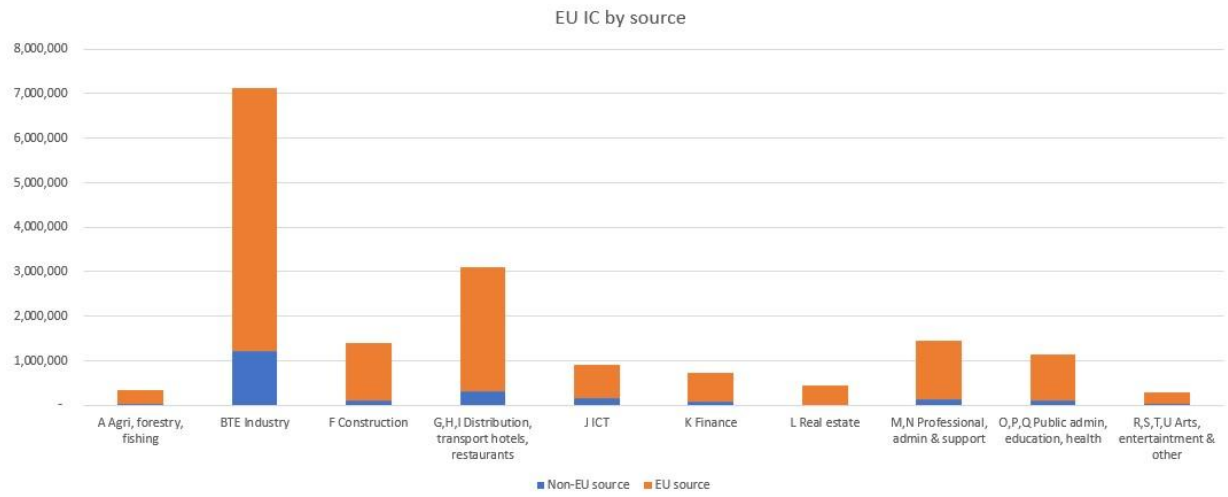


Figure 14 refers to intermediate consumption of EU Industry by geographic source. The top five EU countries contribute 67% of EU Industry intermediate consumption. At €1.5 trillion (26%), Germany is the largest contributor followed by Italy (€850 billion or 14%), France (€765 billion 13%) and Spain (€490 billion or 8%) Non-EU inputs make up €1.2 billion or 20%.

Figure 15 shows EU Industry's €7.1 trillion worth of intermediate consumption split by sector and origin; €3.5 trillion from the EU and €1.2 trillion from outside the EU. The largest source of EU Industry's intermediate consumption is Industry (61%, or €4.3 billion). The second largest is Distribution, transport hotels & restaurants (€1.3 trillion or 18%). Output by wholesalers (NACE 46) (mostly consisting of trade margins) are the largest component of this at 46%. Land transport makes up 16%, 12% is made by retailers (retailers who also engage in wholesaling), while 11% is made up of firms involved in Warehousing & support activities for transportation. The next largest sector is Professional and Administrative Support (8%), followed by Agriculture (4%).

There are only two sectors outside the EU that provide a substantial level of inputs. These are Industry and Distribution, transport hotels & restaurants (€816 billion and €225 billion respectively).

Figure 14: Source of EU Industry inputs, split by EU country (values)

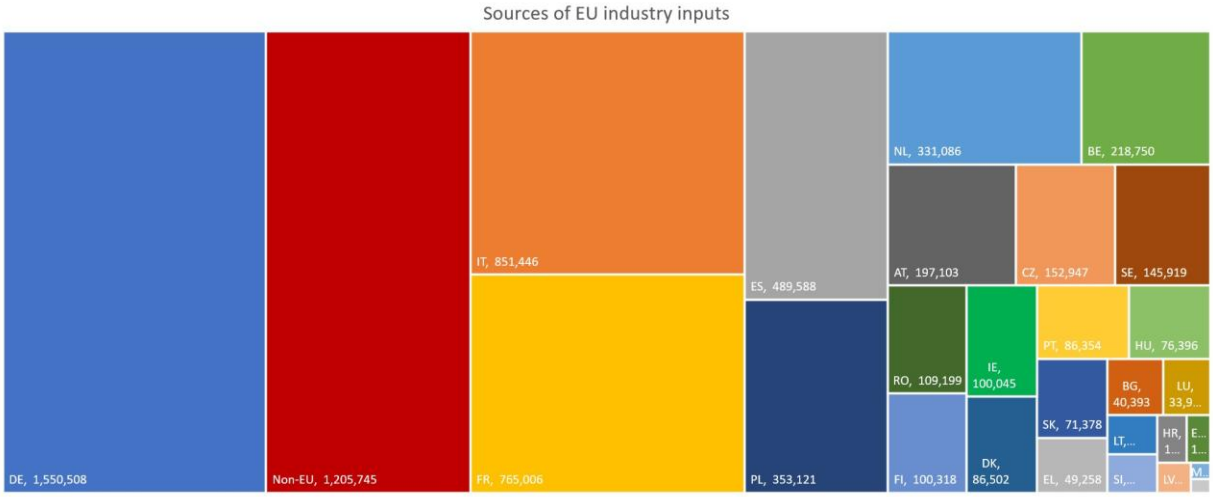


Figure 15: EU Industry inputs by A10 sectors, split by EU and non-EU

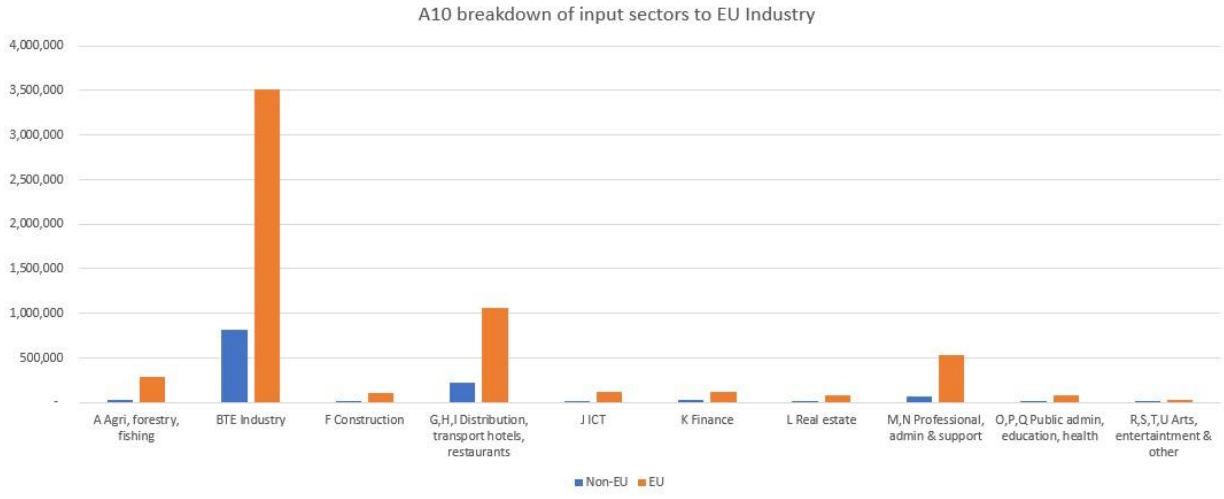
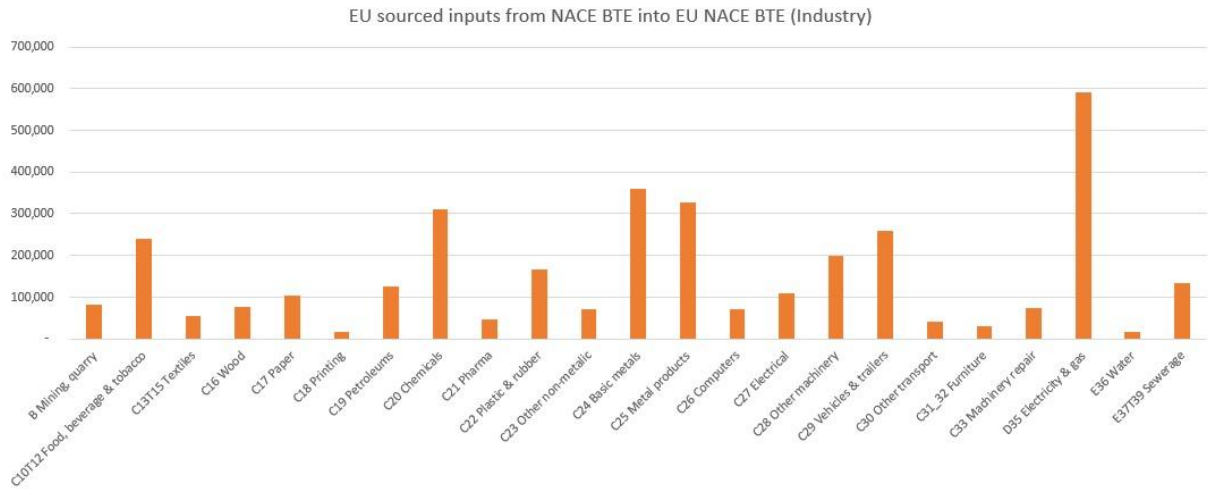


Figure 16: Breakdown of EU Industry inputs supplied by EU Industry, at detailed (A64) level



Next, we split out the 3.5 trillion inputs to EU Industry produced by EU Industry in A64 detail (Figure 16). The largest component is Electricity & gas, (€591 billion or 17%), followed by Basic metals (€358 billion, 10%), Metal products (€328 billion, 9%) and Chemicals (€311 billion, 9%). Vehicles & trailers made up €257 billion (7%), Food, beverages & tobacco made up €241 billion (7%), while Other machinery made up €200 billion (6%).

Figure 17 shows the detailed split of €816 billion non-EU Industry inputs to EU Industry. The Non-EU components of EU Industry's intermediate consumption are very different to their EU equivalent. The majority of these products are Mining & quarrying products (€222 billion, 27%) followed by Chemicals (€85 billion, 11%) and Basic Metals (€73 billion 9%). Other machinery makes up €26 billion (3%), Electrical equipment €46 billion (6%) and Computers makes up €42 billion (5%). Vehicles & trailers make up €40 billion (5%).

Similar to the EU overall, Irish inputs to EU Industry (€100 billion in total) is mostly Industry (Figure 18), worth €54 billion or 54%. The second largest category is Distribution, transport hotels, restaurants (13%). The contribution of Distribution, transport hotels & restaurants is mostly made up of Wholesale markups (71%), Land transport (8%), Air transport (6%) and Warehousing (5%). The remaining sectors are below 10%; ICT 8%, Agriculture 7%, and Professional, admin & support activities (both at 7%).

Figure 17: Breakdown of EU Industry inputs supplied by non-EU Industry, at detailed (A64) level

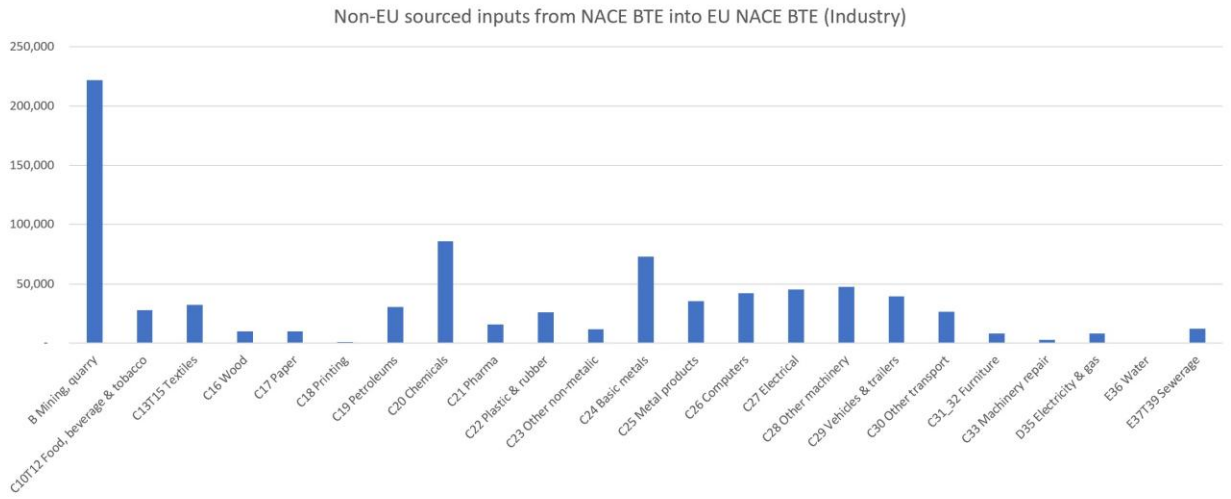


Figure 18: Irish input to EU Industry by NACE A10

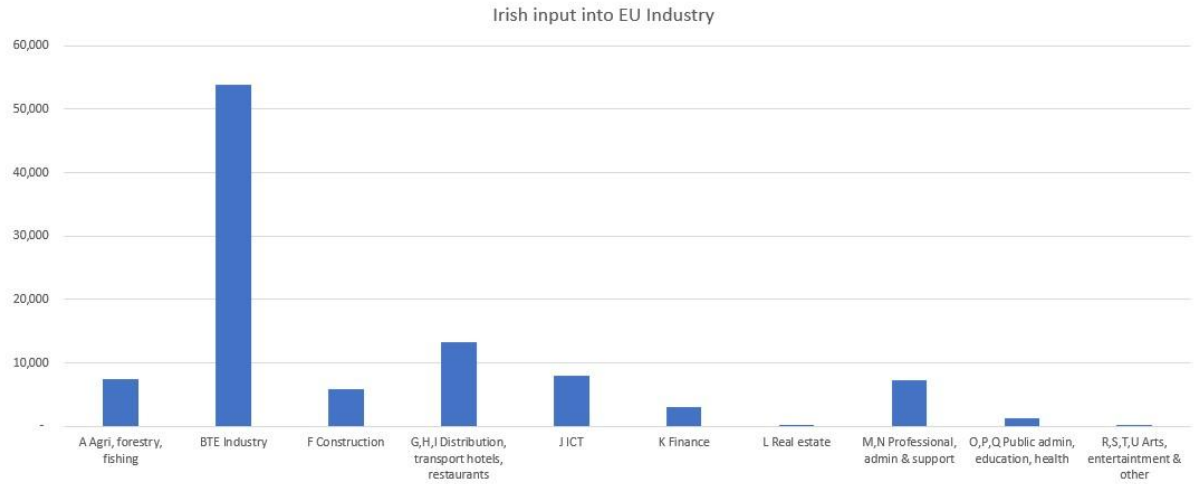


Figure 19: Irish industry's input into EU Industry in detail

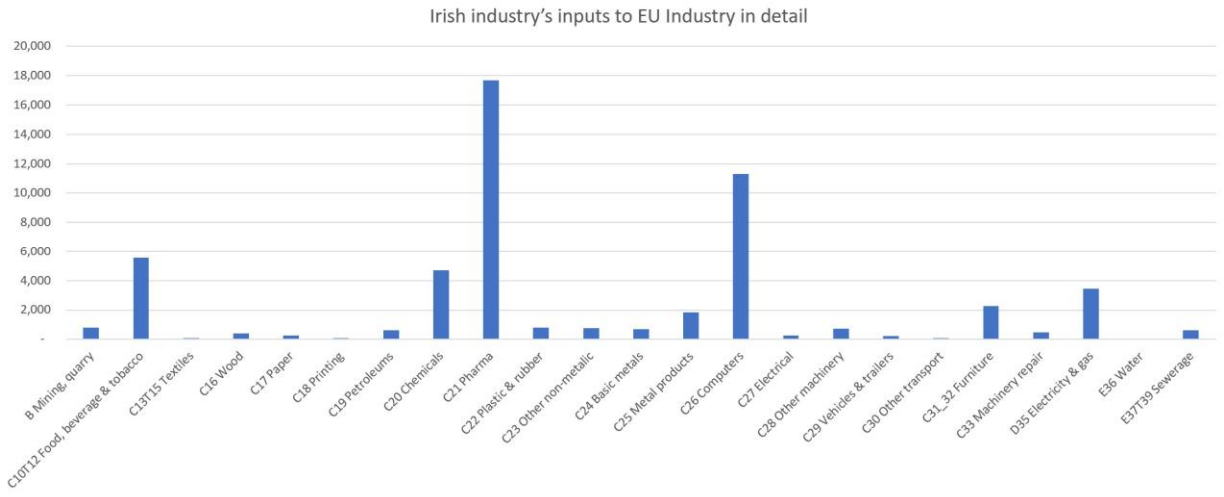


Figure 19 shows a breakdown of Irish industry inputs to EU Industry in detail. The largest contribution is from Pharma (€18 billion, or 33%), followed by Computers (€11 billion, or 21%) and Food, beverages & tobacco (6 billion or 10%). Chemicals make up €4.6 billion (9%), Electricity & gas €3.4 billion (6%) and Furniture €2.3 billion (4%).

7 The impact of increasing the EU-sourced share of intermediate consumption

Finally, in the context of the recent push towards greater European strategic autonomy, we use a very simple stylised model to estimate the direct impact of substituting non-EU inputs for equivalents from within the EU. We emphasise that these estimates are indicative and do not account for costs associated with such a re-alignment including price level differences, skills deficits and retraining, regulatory standards, costs for the rest of the economy associated with re-allocation, capital requirements, and challenges associated with sourcing intermediate products for these intermediates.

We begin with the sectoral distribution of EU intermediate consumption sourced from outside the EU:

$$IC_{(non\ EU)} = \sum_{i=1}^{63} s_{i(non\ EU)}$$

where $s_{i(non\ EU)}$ refers to the percentage share of total EU intermediate consumption from outside the EU that comes from sector i.[14]

The sectoral distribution of EU production for intermediate consumption by sector and country is defined as follows:

$$IC_{(EU)} = \sum_{i=1}^{63} \sum_{j=1}^{27} s_{ij(EU)}$$

where $s_{ij(EU)}$ refers to member state j's percentage share of EU intermediate consumption from within the EU that comes from sector i.

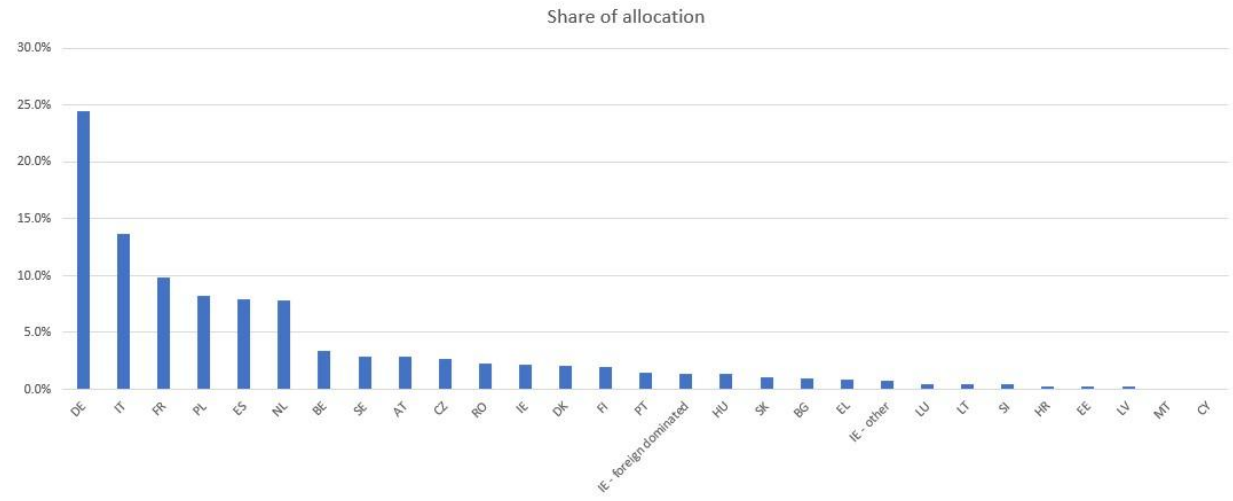
We assume incumbency advantage, where the countries that are already most concentrated in these industries would gain proportionally more from such a re-alignment. Specifically, we assume that the inputs substituted are proportionate to the sectoral split from outside EU, supply by non-EU sectors would be exactly substituted for by their EU equivalents, and that the gains by these EU equivalent sectors by country are distributed according to their presence in the current distribution as follows:

$$Re\ allocated\ IC\ share_{(non\ EU\ to\ EU)j} = \sum_{i=1}^{63} s_{i(non\ EU)} \times s_{i(EU)}$$

This results in a matrix of EU countries with our estimates of their re-allocated shares of intermediate consumption, where the current distribution of EU intermediate consumption to be re-shored sums to one.

Figure 20: Country-level gains from outside the EU

[14] There are 63 sectors. We drop one of the 64 A64 sectors (U, Extraterritorial organisations and bodies) everywhere.



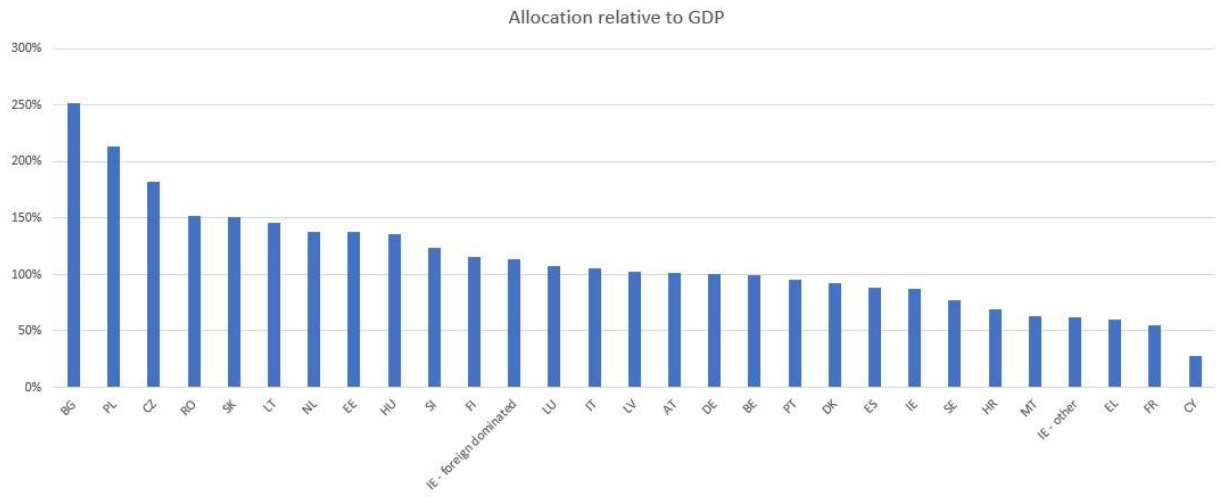
One further addition we make is to divide by countries' share of EU GDP to establish the extent to which they would benefit relative to their economic size. We multiply the subsequent shares by 100 so that the total continues to sum to one.

$$Re\ allctd.IC\ share\ rel.to\ GDP\ share_{(non\ EU\ to\ EU)j} = \frac{Re\ allctd.IC\ share_{(non\ EU\ to\ EU)j}}{GDP_j/GDP_{EU}} \times 100$$

Allocating the distribution of substituting non-EU inputs for EU inputs, we find that the larger countries tend to benefit the most from this re-allocation. Germany would gain 24%, Italy 14%, France 10%, Poland 4%, Spain 8% and the Netherlands 8% of the re-allocated output respectively (Figure 20).

However, scaling these gains by country GDP (Figure 21) provides a very different story. This measure indicates the extent a country would directly benefit from this re-allocation relative to its GDP share. Here we find that countries from central and eastern Europe tend to gain most. Bulgaria would gain over 150% more than what its GDP suggests. Poland would gain 213% more while Czechia would benefit 183% more. At 87%, Ireland would gain 13% less than its GDP share would suggest. Ireland would gain seventh least. Splitting Ireland into MNE and domestic, we find that the MNE sector would gain 14% more than its GDP share would suggest, while the domestic sector would gain 38% less than its GDP share would suggest.

Figure 21: Country-level gains, scaled by country GDP share



8 Conclusion

This paper adds to our understanding of the sectoral interlinkages in the Irish economy and how it relates to the wider EU economy. We find that while the Irish economy is highly concentrated on a GVA basis (a measure that has globalisation-related challenges in Ireland), it is much less concentrated measured by employment, and on the basis of three measures that take sectors' input-output interdependencies into account. The MNE and domestic sectors each account for close to half of economic output. Their activity is very different but there is still a sizeable interlinkage between them.

We also examine the interlinkages of the EU economy by country and sector in the context of the recent push towards European strategic autonomy. Most of the EU's non-EU Industry inputs is from the Manufacturing sector. Moving towards increased self-sufficiency would cause increased EU production in these sectors. Assuming incumbency advantage, where the countries that are already most concentrated in these industries would gain more from such a re-alignment our results suggest that central and eastern member states would benefit most, relative to their economic size. Ireland would benefit seventh least. Splitting the Irish economy into two (foreign

MNE dominated sectors and the rest), we find that MNE sector would benefit more than the EU average from such a re-allocation while the domestic sector is amongst those to benefit least.

We believe these FIAGRO IO tables open up new possibilities for analysis of Ireland and the EU in the context of the potential for large changes in international supply chains. Although much less precise than the main macroeconomic aggregates, these datasets are detailed and go well beyond the conventional conceptual framework for understanding the economy. There is plenty of merit in further exploring the changes to the structure of the economy over time, in particular the interlinkage of the MNE and domestic sectors. Further paths of research could include more precisely splitting the MNE and domestic sectors, potentially following the approach of O'Grady (2024). Another would be to follow Timoney (2023) (and the direction of much of the recent literature) in estimating domestic and international input-output linkages based on output* and intermediate consumption*.

There is also more to discover about the production linkage between the industrial sectors and the components of final uses in the economy: final consumption expenditure, gross capital formation and their subcategories. There is also the scope to apply additional measures from network analysis to these data (the approaches for which can be found in our literature review), including visualising the Irish and EU sectoral and inter-country networks, measuring resilience through stress testing sectors, and clustering analysis. We leave these opportunities to future research.

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9 Appendix

Figure 22: Irish output by location of use

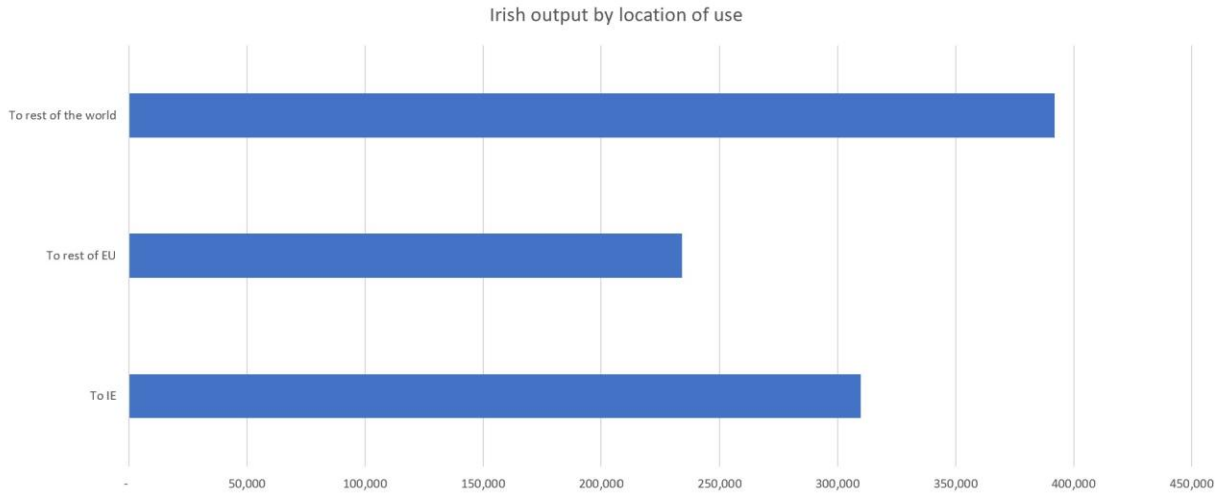


Figure 23: Irish output to rest of EU by country

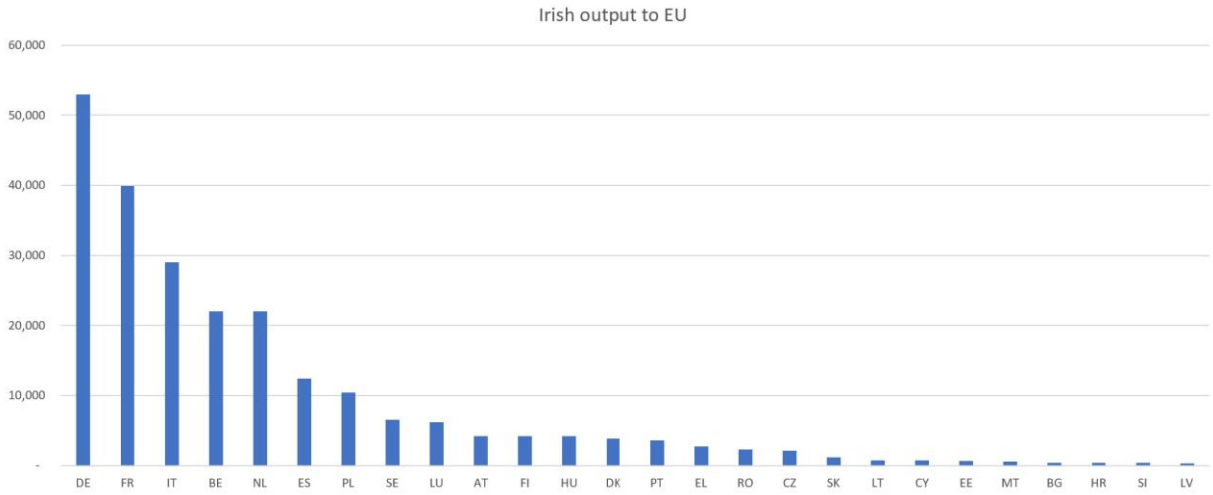


Figure 24: Irish output to rest of world by country

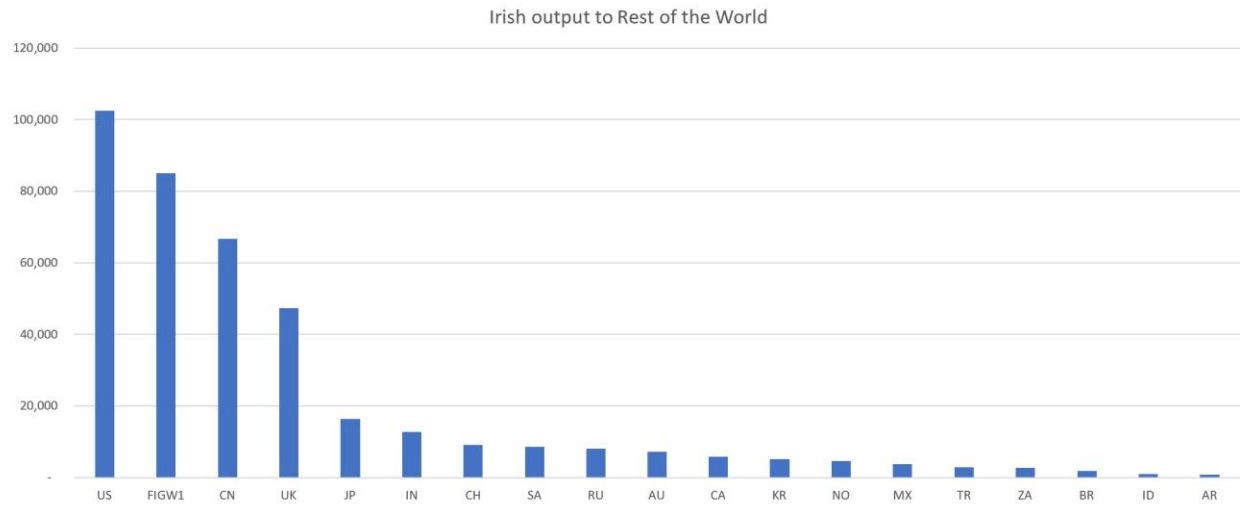
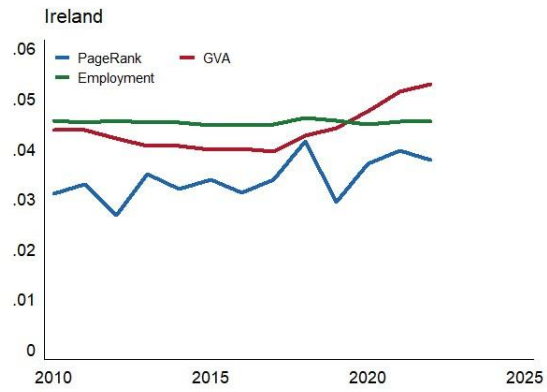
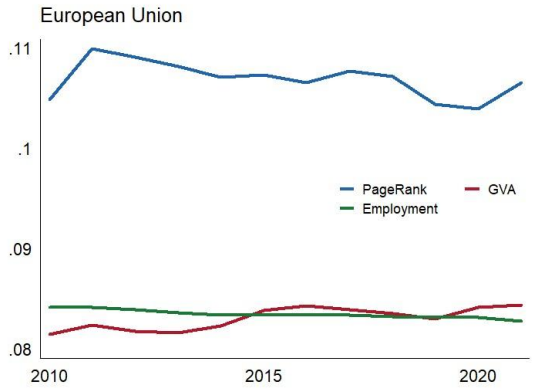


Figure 25: Sectoral concentration over time (A64)

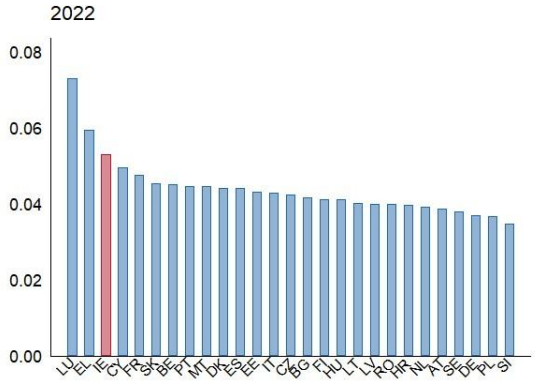


(a) Ireland

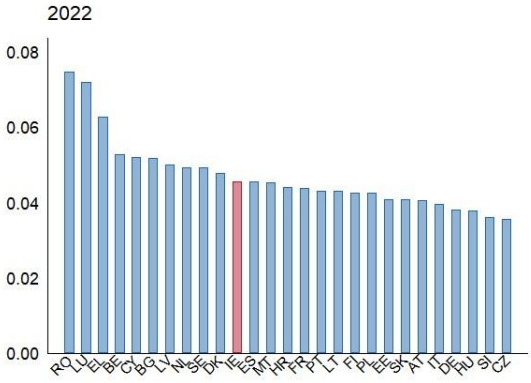


(b) European Union

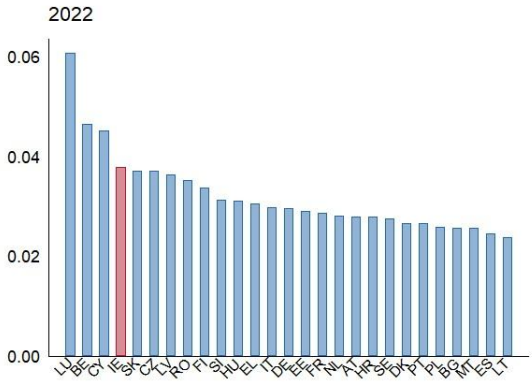
Figure 26: Sectoral concentration using HH index: Ireland in EU context (A64): GVA, employment, PageRank



(a) GVA



(b) Employment



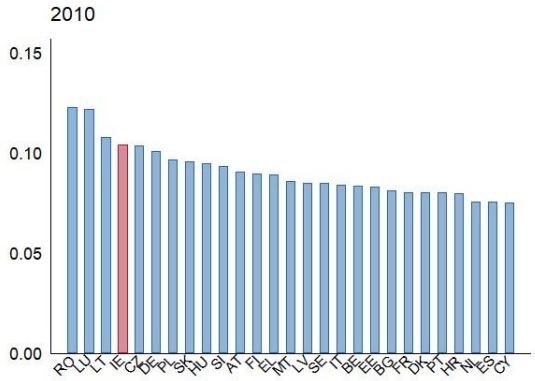
(c) PageRank

Table 1: Irish output by source and destination in 2022

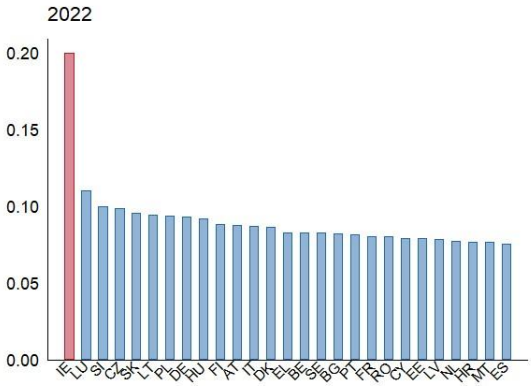
	Billions			Percent	
	Overall	MNE	Domestic	MNE share (%)	Domestic share (%)
Overall output	936	521	415	56	44
Sent abroad	626	479	147	77	24
For final uses abroad	277	229	48	83	17
For IC abroad	349	250	99	72	29
For final uses in Ireland	159	9	151	5	95
For IC in Ireland	150	34	117	22	78
Consumed by MNE sector	49	22	27	44	56
Consumed by domestic sector	101	12	89	12	88

Final uses are final consumption expenditure, gross fixed capital formation, and changes in valuables and inventories.

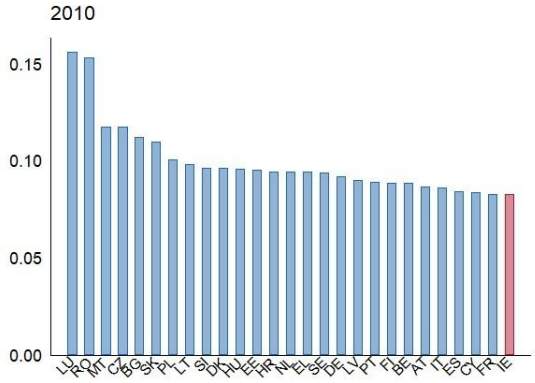
Figure 27: HH index by country (A21): 2010 and 2022



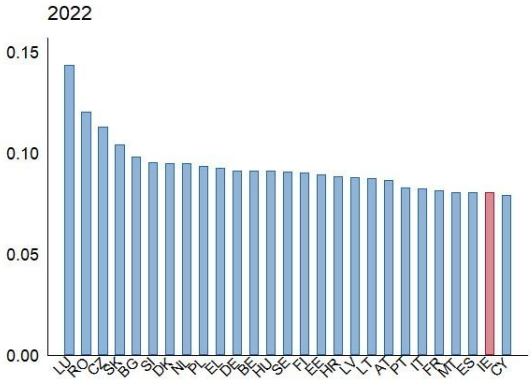
(a) GVA: 2010



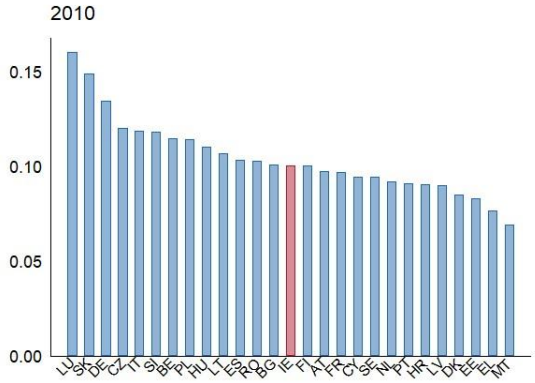
(b) GVA: 2022



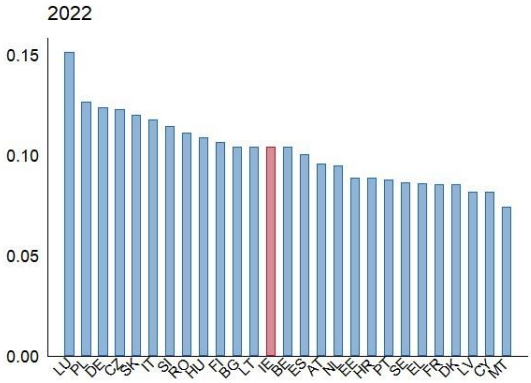
(c) Employment: 2010



(d) Employment: 2022



(e) PageRank: 2010



(f) PageRank: 2022

Table 2: EU composition by country (percentage shares) in 2022

	GDP (GNI* for Ireland)	Exports	Imports	Population	Land area
DE Germany	24.9	20.3	19.9	18.6	8.7
FR France	16.7	10.9	12.1	15.2	13.3
IT Italy	12.6	7.9	8.6	13.2	7.3
ES Spain	8.6	6.1	6.2	10.6	12.1
NL Netherlands	6.3	10.7	10.1	3.9	0.9
PL Poland	4.2	4.6	4.7	8.4	7.6
BE Belgium	3.5	6	6.3	2.6	0.7
SE Sweden	3.5	3.3	3.3	2.3	10.8
AT Austria	2.8	3.1	3.2	2	2
DK Denmark	2.4	3	2.7	1.3	1
CZ Czechia	1.8	2.3	2.4	2.4	1.9
RO Romania	1.8	1.4	1.6	4.3	5.8
FI Finland	1.7	1.4	1.5	1.2	8.2
IE Ireland	1.7	8	5.8	1.1	1.7
PT Portugal	1.5	1.4	1.5	2.3	2.2
EL Greece	1.3	1.1	1.4	2.3	3.2
HU Hungary	1.1	1.7	1.9	2.2	2.3
SK Slovakia	0.7	1.2	1.3	1.2	1.2
BG Bulgaria	0.5	0.7	0.7	1.5	2.7
LU Luxembourg	0.5	1.8	1.6	0.1	0.1
HR Croatia	0.4	0.5	0.5	0.9	1.4
LT Lithuania	0.4	0.7	0.7	0.6	1.6
SI Slovenia	0.4	0.6	0.6	0.5	0.5
CY Cyprus	0.2	0.3	0.3	0.2	0.2
EE Estonia	0.2	0.4	0.4	0.3	1.1
LV Latvia	0.2	0.3	0.3	0.4	1.6
MT Malta	0.1	0.3	0.2	0.1	0

Sorted by GDP share (GNI* for Ireland). Ireland's GDP share is 3.2%

Figure 28: Ireland's economic relationship is more important as a supplier than a buyer: Rest of EU IC of country as % of country IC of rest of EU

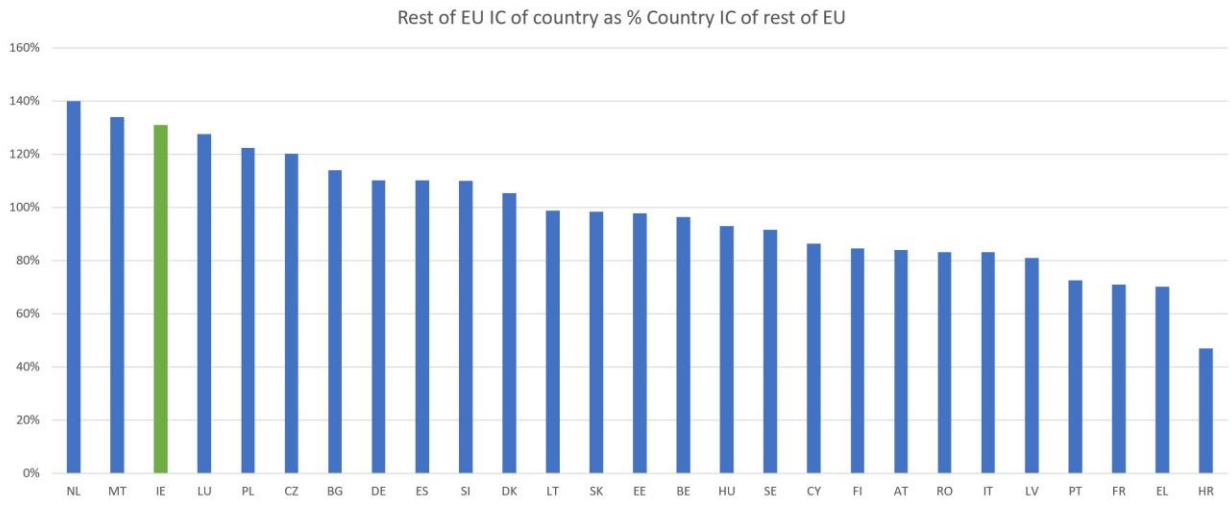


Figure 29: Ireland's share of output to the EU (including Ireland) is the lowest in the EU

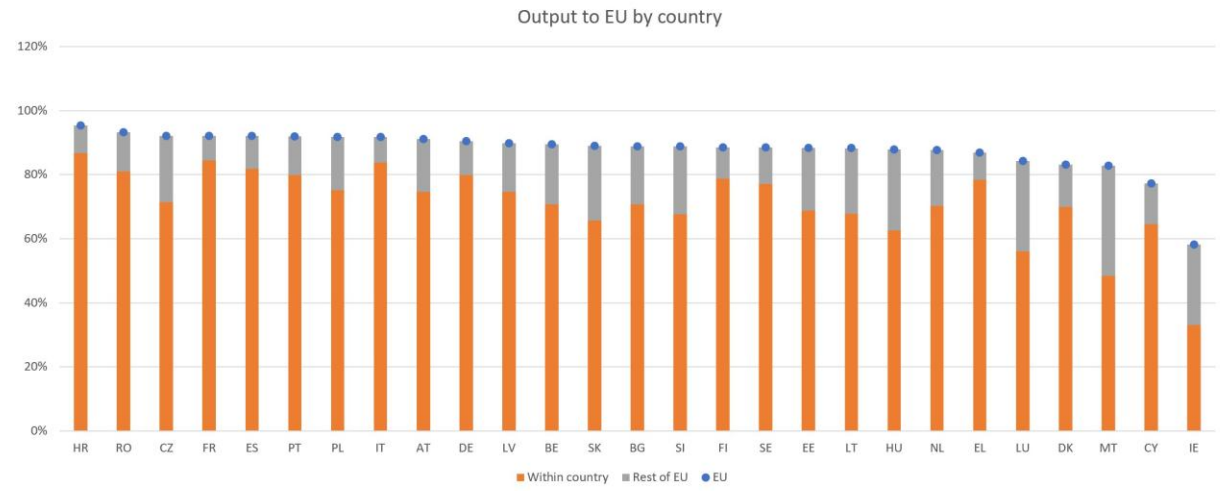
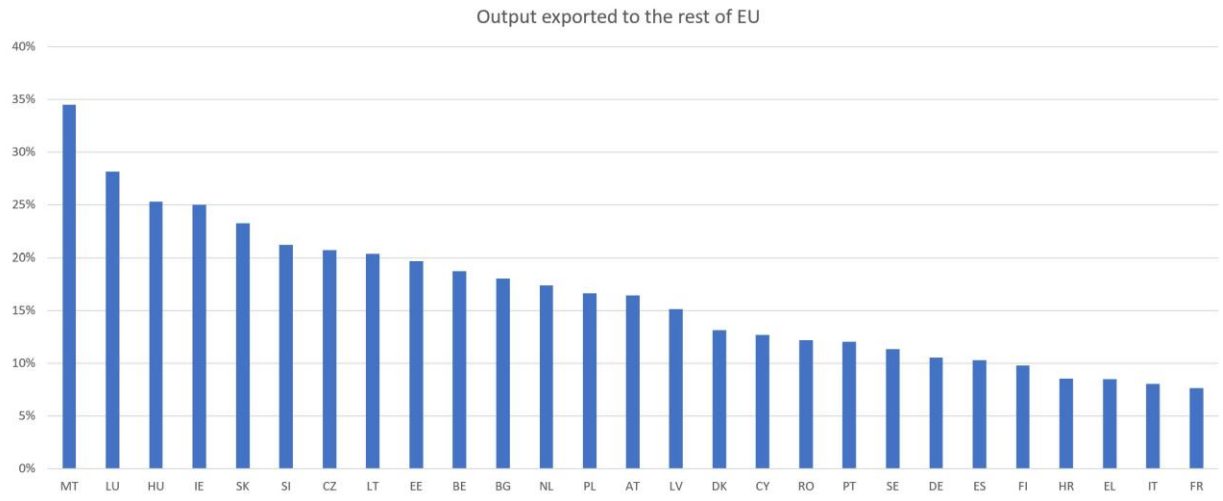


Figure 30: Ireland's share of output to the rest of EU is among the highest in the EU


Output exported to the rest of EU
40%
35%
30%
25%
20%
15%
10%
5%
0%
MT
LU
HU
IE
SK
SI
CZ
LT
EE
BE
BG
NL
PL
AT
LV
DK
CY
RO
PT
SE
DE
ES
FI
HR
EL
IT
FR