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Sectoral Decomposition on Northern Ireland Input-Output Tables

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Introduction

Northern Ireland, like many regions worldwide, is undergoing a green revolution, with a commitment to achieving net-zero emissions by 2050 (Northern Ireland Assembly, 2022). Reaching this target requires substantial investment across industries connected to the energy sector. While this investment is expected to drive economic growth through increased Gross Value Added (GVA) and employment, it will also have implications for energy prices.

There are several ways in which energy prices may be affected. The first is through rising demand, particularly for electricity, due to the electrification of existing energy use. One of the core aspects, among others, of the green transition is through electrification of demand, i.e. heating and transport systems onto the electrical grid—for example, through greater adoption of heat pumps and electric vehicles (IEA, 2025). As with any commodity, an increase in demand can influence pricing with this likely increasing with level depending on supply levels.

The second factor affecting energy prices is the investment and operation of energy networks, such as electricity and gas infrastructure. Increased electricity demand requires significant upgrades to transmission and distribution systems, with estimated costs in the billions of pounds (NIE Networks, 2023). As this investment is not privately funded, consumers are likely to bear the cost, primarily through higher electricity prices (Ofgem, 2024).

Finally, renewable energy generation will also impact energy prices. Research suggests that greater reliance on renewables—depending on the technology used—can help stabilise or even reduce energy prices by decreasing dependence on volatile fossil fuel imports, used as both a primary consumed fuel and in electricity generation (Hosius et al, 2023).

The precise overall effect on energy prices, whether an increase or decrease, remains uncertain without a comprehensive energy system modelling analysis. However, economic accounting can be conducted to identify the industries most likely to be affected by changes in energy costs.

This policy brief analyses the Northern Ireland economic accounts with a focus on the linkages of the energy industry. While we report some estimated economic impacts, the main emphasis is on identifying the industries exposed to changes in the energy sector, rather than quantifying the exact value of those impacts. To test the linkages with the energy industry a hypothetical extraction methodology is applied, in this case extraction of the energy industry from economic accounts. The results include the value, which represents the reduction in sectoral output in millions of pounds; the normalised result, calculated as the industry's reduction divided by the total industrial output; and Ghosh multipliers which illustrate how interlinked each industry is within the economy.

As with any modelling exercise there are some limitations including the use of fixed-coefficient models that do not capture substitution or behavioural response and the assumption of fixed prices. Further research using dynamic modelling techniques like Computable General Equilibrium (CGE) models is recommended to refine impact assessment of economy-wide changes linked to unit price changes in energy.

Modelling Framework

The primary objective of this policy brief is to conduct a sectoral decomposition analysis of Northern Ireland's Industry-by-Industry Input-Output Tables (IOTs) to assess which industries are most likely to be affected by changes in energy prices linked to the green transition. Several methodologies are used to analyse the IOTs for Northern Ireland.

IOTs are a set of economic accounts that record transactions between industries—such as agriculture and manufacturing—as well as final demand (i.e., final consumers of goods and services such as households, government, exports) within a region over a defined period (typically one year). They illustrate how the output of one industry can either be used as an input for another or sold directly to consumers. In these tables, rows represent the sales of individual industries, while columns indicate the inputs required by each industry to meet its output. Additionally, sales to final consumers—including households, government, and exports—are also represented in the rows. Other production inputs, such as imports, wages, and taxes, are included in the columns. By representing these interdependencies, IOTs allow for the analysis of economic flows within a region, helping to assess how factors such as policy changes or investment may impact different industries.

The Northern Ireland IOTs have been produced regularly by NISRA since 2017, with the most recent tables available for 2021 (NISRA, 2025). However, there is a time lag between the reference year and the publication of these tables due to the need for data collection, analysis, and verification. The NISRA tables provide data for 63 industrial sectors based on the Standard Industrial Classification (SIC) framework, alongside final demand categories, including households, government, and exports (divided into the Rest of the UK, the Republic of Ireland, the European Union, and the Rest of the World[1]).

In this brief, we analyse four tables covering the period from 2017 to 2020 as these were the latest available at the time of analysis. However, it is important to note that the accuracy of the 2020 calendar year tables may be affected due to economic disruptions caused by COVID-19. The information in the IOT tables can be understood as a series of simultaneous equations, represented as:

$$x_i = z_{i,1} + \cdots + z_{i,j} + \cdots + z_{i,n} + f_i \qquad (1)$$

Where:

- x_i is the output of industry i;
- f_i is the final demand for industry i and;
- $z_{i,j}$ representing the industrial sales from industry i to industry j.

In Industry by Industry (IxI) IOTs $i = n$ thus the industrial sales for Northern Ireland can be represented by a 63 by 63 matrix. In traditional Input-Output analysis, known as demand-driven analysis, the focus is on backward linkages—examining how demand in one industry flows through the supply chain and influences economic activity, either positively or negatively. This type of analysis is conducted by first developing the Leontief Inverse Matrix and then introducing a demand shock (Miller & Blair, 2022).

However, this policy brief focuses on estimating the forward linkages—examining how changes in one industry affect downstream industries, i.e., those that rely on the impacted industry as part of their supply chain.

1 The analysis in this policy brief is focussed only on industrial sectors.

To analyse this, we use the supply-side calibration of the Input-Output model, known as the Ghosh model. The first stage of our decomposition analysis involves a simple calculation of the proportion (denoted by b) of sales to each industry (j) by from the energy industry (ene).

$$b_{\mathrm{ene}} = \frac{z_{\mathrm{ene},1}}{x_{\mathrm{ene}}} + \frac{z_{\mathrm{ene},2}}{x_{\mathrm{ene}}} + \cdots + \frac{z_{\mathrm{ene},n}}{x_{\mathrm{ene}}} \quad (2)$$

This analysis can reveal changes in the value of energy sales and identify key upstream industries that heavily rely on energy inputs (by value) and are therefore most at risk from fluctuations in energy prices. However, this metric only indicates the proportion of energy sales to other industries without considering their relative size. To address this, we also calculate a normalised parameter that accounts for an industry's reliance on energy relative to its total output. Industries with higher reliance are more 'at risk' from changes in energy prices.

$$\mathrm{NENE}_j = \frac{z_{\mathrm{ene},j}}{x_j} \quad (3)$$

Next, we calculate the Ghosh multiplier for each of the industries with the IOT to determine how interlinked energy is with the rest of economy, in comparison with other industries. For this we first extend equation 2 for the full IOT such that:

$$B = \begin{bmatrix} b_{1,1} & b_{1,2} & b_{1,n} \\ b_{2,1} & b_{2,2} & b_{2,n} \\ b_{i,1} & b_{i,2} & b_{i,n} \end{bmatrix} = \begin{bmatrix} \frac{z_{1,1}}{x_1} & \frac{z_{1,2}}{x_1} & \frac{z_{1,n}}{x_1} \\ \frac{z_{2,1}}{x_2} & \frac{z_{2,2}}{x_2} & \frac{z_{2,n}}{x_2} \\ \frac{z_{i,1}}{x_i} & \frac{z_{i,2}}{x_i} & \frac{z_{i,n}}{x_i} \end{bmatrix} = \begin{bmatrix} \frac{1}{x_1} & 0 & 0 \\ 0 & \frac{1}{x_2} & 0 \\ 0 & 0 & \frac{1}{x_i} \end{bmatrix} \begin{bmatrix} z_{1,1} & z_{1,2} & z_{1,n} \\ z_{2,1} & z_{2,2} & z_{2,n} \\ z_{i,1} & z_{i,2} & z_{i,n} \end{bmatrix} = X^{-1}Z$$

Using the standard IO notation B, X^{-1} and Z are matrices of allocation coefficients, output and inter industrial sales respectively. Following from Chapter 7 of Miller and Blair (2022) the Ghosh model is calculated as:

$$X = (I - B)^{-1}V \quad (4)$$

With I (an NxN identity matrix) and V (a matrix of value added). Ghosh multipliers are calculated as:

$M_i = \sum_{i=1}^{n} G_{i,j}$ where $G = (I - B)^{-1}$.

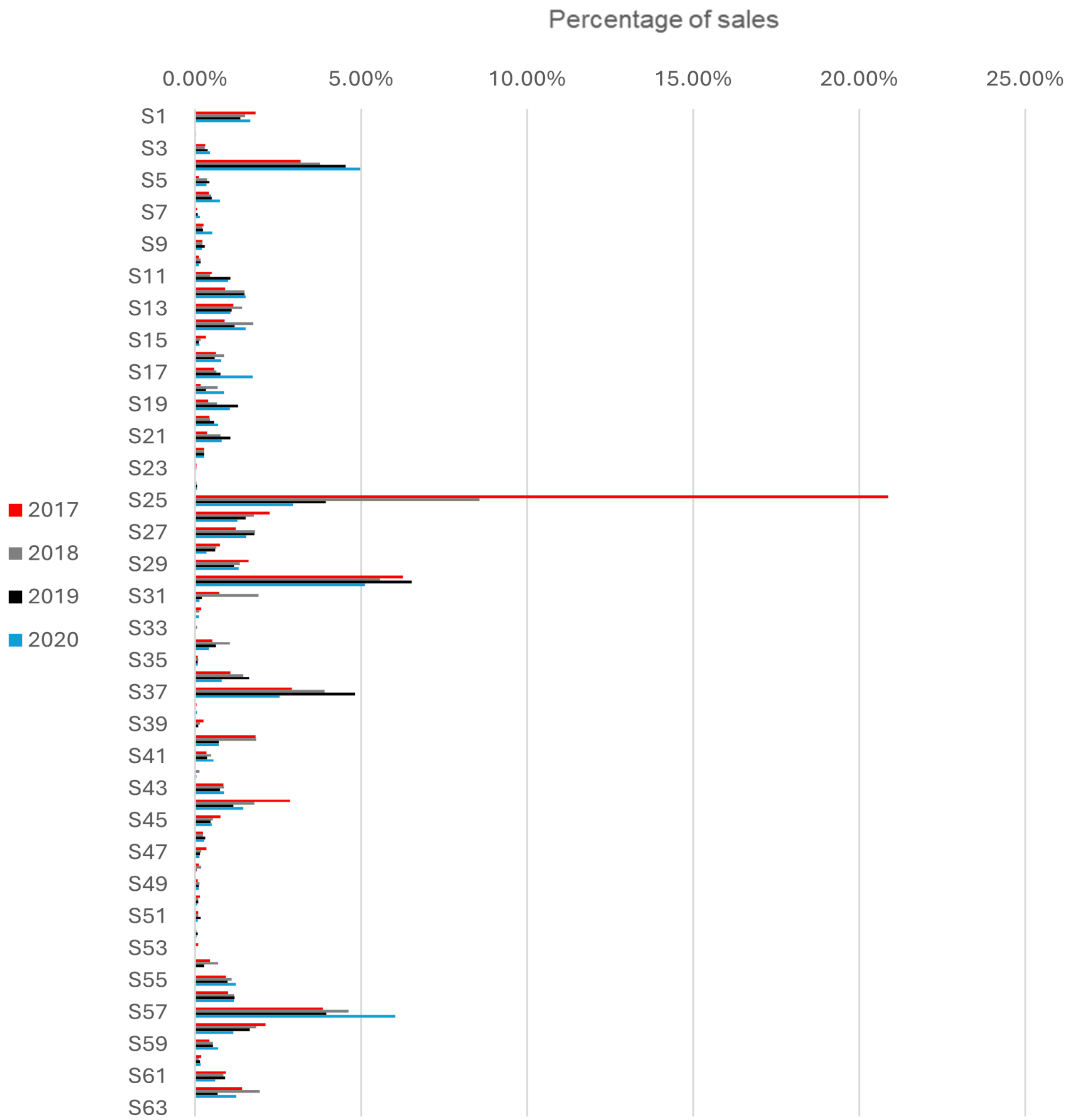
Using data from the Ghosh model (Equation 4), we apply the hypothetical extraction method to assess the current importance of the energy industry to the Northern Ireland economy as a whole, as well as to the industries that rely on its output. Hypothetical extraction is widely used in Input-Output (IO) literature (Tsirmokos, 2024, Li, ll & Song, 2022) to evaluate a sector's contribution to overall economic activity, inter-industry linkages, and systemic risk. In this brief, we perform a total hypothetical extracting by setting $b_{i,n} = 0$ in equation 4.

When applying the hypothetical extraction, two types of results are identified. The first is the value, which represents the reduction in sectoral output in millions of pounds. The second is a normalised result, calculated as the industry's reduction divided by the total industrial output.

Results

Chart 1 displays the results for the simple proportion of output calculation between 2017 and 2020.

Chart 1: Sales from energy to other industries 2017-2020[2]



Source: *Author's calculation*

This simple decomposition analysis highlights several key insights into the importance of the energy sector (s25) to other industries[3]. Here we only focus on intra-industry sales, i.e., transactions between businesses with the energy sector, with households, government and exports not being analysed in this report.

Several manufacturing industries are particularly dependent on energy, including food products (s4) and pharmaceuticals (s12), which accounted for 4.98% and 1.54% of energy sales, respectively.

2 For ease of formatting industrial names have been replaces by s1-s63. Appendix A maps these industries.

3 The 2017 energy proportion is more than double that of the other years and there a number of reasons why this could be the case. One would be that the 2017 was the first year of publication and some experimental/new methods or data sources were used which were then refined over the years.

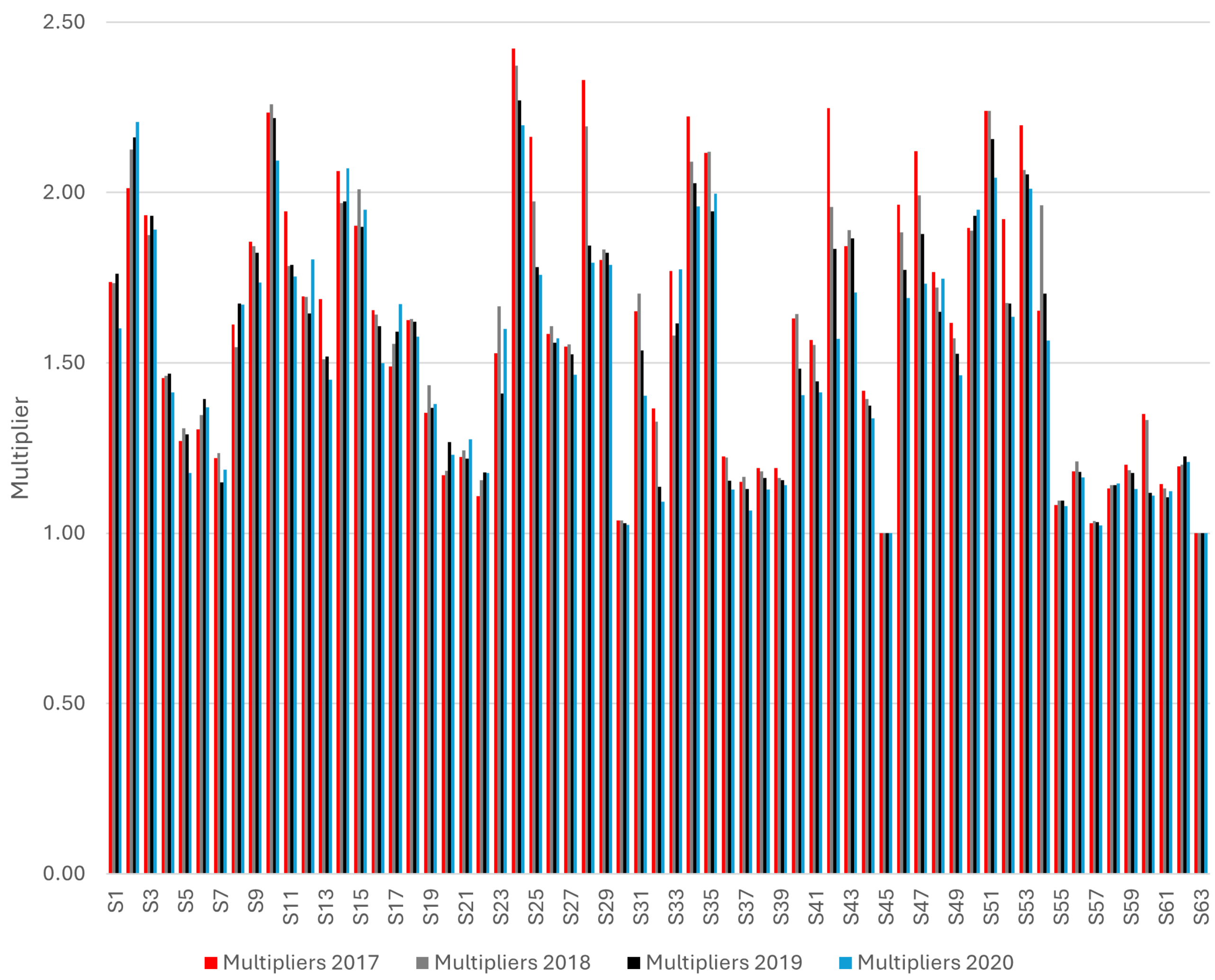
Between 2017 and 2020, the proportion of energy sales to these industries increased by 1.79 percentage points for food products and 0.62 percentage points for pharmaceuticals.

Both industries play a crucial role in the Northern Ireland economy—food production is essential for local consumption and household spending, while pharmaceuticals are a key export sector. Rising energy prices could impact these industries, leading to higher food costs for households and reducing the global competitiveness of Northern Ireland's pharmaceutical sector.

Wholesale trade, retail trade, and the food and beverage industry are also closely linked to household spending and rely significantly on inputs from the energy sector. In 2020, wholesale trade (s29) accounted for 1.31% of energy sales, while retail trade (s30) and the food and beverage (s37) industry made up 5.12% and 2.55%, respectively. This suggests that, beyond the direct impact of rising energy prices, households are also likely to experience indirect effects through higher costs for goods and services.

Chart 1 also highlights that key public sectors account for a significant share of energy sales. In 2020, the education sector (s56) made up 1.18% of energy sales, while health (s57) and residential care accounted (s58) for 6.03% and 1.16%, respectively. Rising energy prices in these sectors could place additional pressure on government budgets and influence how public services are funded. **Chart 2** presents the Ghosh multipliers for each industry, providing further insight into their economic interdependencies.

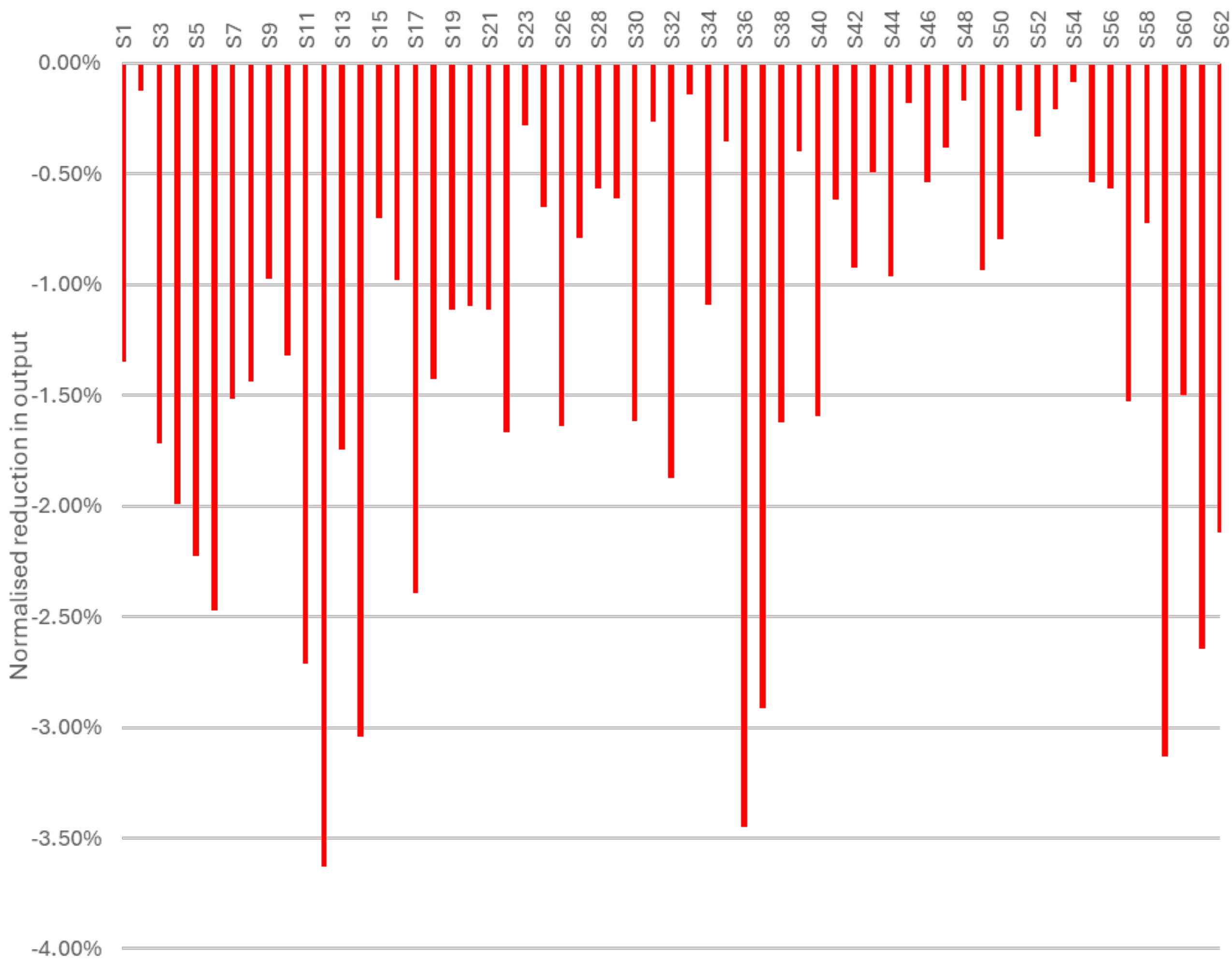
Chart 2: Northern Ireland IOT Ghosh Multipliers



Source: *Author's calculation*

The Ghosh multipliers from **Chart 2** illustrate how interlinked each industry is within the economy. On average, the multipliers were 1.61 in 2017, 1.59 in 2018, 1.54 in 2019, and 1.51 in 2020. In each year, the energy industry (S25) had a higher-than-average multipliers, indicating its strong interconnectedness (i.e., sales) with other sectors. However, this multiplier has declined over time, from 2.16 in 2017, 1.97 in 2018, 1.78 in 2019, to 1.76 in 2020. There are several possible explanations for this decline. One plausible reason is that businesses are becoming more energy-efficient—adopting improved technologies, energy-efficient appliances, and optimised industrial processes. Additionally, it may suggest that the energy sector's overall role - as an input in producing economic activity (GVA/employment) is gradually diminishing.

Chart 3: Industrial Normalised results of Hypothetical Extraction in 2020



Source: *Author's calculation*

As is to be expected, from **Chart 3**, the hypothetical extraction shows that the energy industry is an important input to many industries throughout the economy and any change would lead to significant impacts throughout. The five most impacted industries, in terms of value and normalised output, are outlined in **Table 1**.

Table 1: Five most impacted industries by value and normalised output in 2020 Hypothetical Extraction

Value		Normalised output[4]	
Industry	£ Million	Industry	Change
Human health care activities (s57)	-97.74	Manufacture of pharmaceuticals	-3.63%
Food products (s4)	-86.87	Accommodation (s36)	-3.45%
Retail trade (s30)	-64.83	Creative arts services (s59)	-3.13%
Construction (s27)	-60.36	Manufacturing of non-metallic products (s14)	-3.04%
Food and beverage services (s37)	-33.06	Food and beverage services (s37)	-2.93%

Source: *Author's calculation*

In terms of value loss, industries such as healthcare services, food products, and retail trade experience the greatest economic downturns. These sectors contribute significantly to overall economic activity, so any disruption in the energy supply (including prices) could result in substantial losses across the economy. The top five industries affected align closely with the trend of percentage of sales from **Chart 1**.

On the other hand, when considering the normalised percentage change in output, industries such as manufacture of pharmaceuticals, accommodation and creative arts services face the steepest declines. While many of these sectors may have a lower absolute economic value, they are disproportionately impacted by energy price disruptions due to their heavy reliance on a stable energy supply for operations.

4 For comparison, Northern Ireland businesses spend around 2% of turnover of energy purchases in 2019 (NI Executive, 2019).

Summary and Conclusions

This policy brief investigates the economic interlinkages between the energy sector and other industries in Northern Ireland using Input-Output analysis. As Northern Ireland transitions towards net-zero emissions by 2050, the energy sector is expected to undergo major changes, including rising electricity demand, infrastructure investment, and the expansion of renewable energy. These changes are likely to influence energy prices, with knock-on effects across the economy.

Using Northern Ireland's IOTs from 2017 to 2020, the brief applies a forward linkage analysis to identify industries most exposed to energy sector fluctuations. The analysis includes three methods:

1. **Proportional energy sales to other industries**
2. **Ghosh multipliers to assess inter-industry linkages**
3. **Hypothetical extraction to estimate potential output loss if the energy sector were removed**

Key findings include:

- Manufacturing sectors such as food products and pharmaceuticals are highly dependent on energy inputs and have seen rising exposure from 2017 to 2020.
- Retail, wholesale, and hospitality sectors, which are closely tied to household consumption, also show significant exposure.
- Public services, including education, health, and residential care, are notable consumers of energy, indicating potential fiscal pressures from rising costs.
- Ghosh multipliers confirm the energy sector's high level of interconnectedness, although its influence has declined slightly over time.
- Hypothetical extraction analysis reveals that energy sector disruptions would significantly affect both high-value and energy-intensive industries, with retail trade and human health activities among the most impacted by absolute output loss. Manufacture of pharmaceuticals and accommodation face the steepest proportional impacts.

The analysis highlights the need for targeted policy interventions to mitigate the risks of energy price volatility on vulnerable sectors. While this brief uses fixed-coefficient models that do not capture substitution or behavioural responses, it provides a strong foundation for identifying at-risk industries. Further research using dynamic modelling techniques like Computable General Equilibrium (CGE) models is recommended to refine impact assessments and support resilient policy design.

References

IEA. (2025). Electrification. Available from: IEA website.

Hosius, E., Sebbab, J., Wacker., B., & Schluter. (2023). The impact of offshore wind energy on Northern European wholesale electricity prices. Applied Energy, 341, 120910, https://doi.org/10.1016/j.apenergy.2023.120910.

Li, Z., Li, Z., & Song, Y. (2022). Identification of key provinces and sectors for energy conservation in China: Linkage analyses based on the modified hypothetical extraction method. Energy Strategy Reviews, 44, 100998, https://doi.org/10.1016/j.esr.2022.100998.

NI Executive. (2019). The path to net zero energy. Available from: DfE Website.

NIE networks. (2023). A future network for all: NIE networks business plan. Available from: RP7 outline.

NISRA. (2025). NI Economic Accounts Project. Available from: NISRA website.

Northern Ireland Assembly. (2022). Climate Change Act (Northern Ireland) 2022. Available from: legislation documentation.

Ofgem. (2024). Electricity transmission infrastructure: what's changed. Available from: Ofgem website

Miller, R., & Blair, R. (2022). Input-Output Analysis: Foundations and Extensions. ISBB: 9781108484763

Tsirmokos, K. (2024). Applying the hypothetical extraction method to investigate the interindustry greenhouse gas emissions linkages in the Greek economy, Journal of Environmental Economics and Policy, 13(1), pp 93-109. https://doi.org/10.1080/21606544.2023.2221206.

Appendix A – Fixed Exports with price changes

s1	Crop And Animal Production, Hunting and Related Service Activities
s2	Forestry and fishing
s3	Mining and quarrying products
s4	Manufacture of food products
s5	Manufacture of beverages and tobacco products
s6	Manufacture of Textiles
s7	Manufacture of wearing apparel and leather products
s8	Manufacture of Wood & Products of Wood & Cork, Except Furniture; Manuf. of Articles of Straw
s9	Manufacture of Paper and Paper Products
s10	Printing and Reproduction of Recorded Media
s11	Manufacture of coke, refined petroleum and chemicals
s12	Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations
s13	Manufacture of Rubber and Plastic Products
s14	Manufacture of other non-metallic mineral products
s15	Manufacture of basic metals
s16	Manufacture of fabricated metal products
s17	Manufacture of Computer, Electronic and Optical Products
s18	Manufacture of Electrical Equipment
s19	Manufacture of Machinery and Equipment N.E.C.
s20	Manufacture of Motor Vehicles, Trailers and Semi-Trailers
s21	Manufacture of other transport equipment
s22	Manufacture of Furniture
s23	Other Manufacturing
s24	Repair and installation of machinery and equipment
s25	Energy
s26	Water supply; sewerage and waste management
s27	Construction
s28	Wholesale and Retail Trade And Repair of Motor Vehicles and Motorcycles
s29	Wholesale Trade, Except of Motor Vehicles and Motorcycles
s30	Retail Trade, Except of Motor Vehicles and Motorcycles
s31	Land transport
s32	Water transport
s33	Air transport
s34	Warehousing and support services for transportation
s35	Postal and courier activities
s36	Accommodation
s37	Food and beverage serving activities
s38	Publishing activities

s39	Motion Picture, Video & TV Programme Production, Sound Recording & Music Publishing Activities & Programming and Broadcasting Activities
s40	Telecommunications services
s41	Computer programming, consultancy and related activities
s42	Information services activities
s43	Financial and insuranceactivities
s44	Real estate activities (excluding imputed rent)
s45	Imputed Rent
s46	Legal and accounting activities
s47	Activities of head offices and management consultancy
s48	Architectural and engineering service; Technical Testing and Analysis
s49	Scientific research and development, and advertising and research
s50	Other professional, scientific and technical activities and veterinary activities
s51	Rental and leasing and employmentactivities
s52	Travel agency, tour operator and other reservation services and related services and security and investigation activities
s53	Services to buildings and landscape activities
s54	Office administrative, office support and other business support activities
s55	Public Administration And Defence; Compulsory Social Security
s56	Education
s57	Human health activities
s58	Residential Care & Social Work Activities
s59	Creative, arts and entertainment services and libraries, archives, museums and other cultural activities
s60	Gambling and betting activities
s61	Sports services and amusement and recreation activities
s62	Other service activities
S63	Activities Of Households as Employers of Domestic Personnel

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