

Research Bulletin 20/8 | Understanding Economic Shocks Using the FAI HEM Model for Northern Ireland

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Summary

The impact of businesses extends to more than just the products they create and the turnover they generate. Businesses have complex supply chains that stretch across the whole of Northern Ireland's economy and beyond. When businesses face sharp falls in demand, these complex supply chains make it difficult to understand the true impact on output and employment across Northern Ireland. However, three types of models are well suited to understanding supply chain shocks, each useful in different circumstances. This report looks at one of these – the Fraser of Allander Institute Hypothetical Extraction Method Model for Northern Ireland (or FAI HEM for Northern Ireland).

A Hypothetical Extraction Method Model (HEM) is well suited to analysing negative demand shocks to industries, groups of industries, sub-sectors and activities that span multiple industries (e.g. renewable activities). Recent examples of the usefulness of this modelling are plentiful – from the effective closure of several industries during the coronavirus pandemic to the considerable job and output losses expected by some large firms. This article explains the HEM and uses the FAI HEM for Northern Ireland to examine the economic impact of 12 selected industries experiencing a 10% fall in demand.

Introduction

Three modelling techniques typically used for quantitatively understanding supply chains are Input-Output (IO) modelling, the Hypothetical Extraction Method (HEM) and Computable General Equilibrium Modelling (CGE). IO, HEM and CGE all have different strengths and weaknesses which makes each an important part of an applied economist's toolkit.

The primary use of a HEM is for removing economic activity from the economy, for instance shutting down the food manufacturing sector. For shocks that are additional to the economy standard IO modelling or a CGE should be used. And for supply side shocks, or demand shocks which are large enough to have a large impact on prices, CGE models should be used. As an example, in August 2019 Fraser of Allander Institute analysed the possible long-term economic impacts of a range of Brexit scenarios for Northern Ireland using a CGE model¹.

It is important to note that analyses can be quickly run and interpreted using IO models and HEMs, whereas CGE models require significantly more time. Typically CGE models are also aggregated to fewer sectors.

What are IO tables?

Input-Output (IO) tables are part of the System of National Accounts (SNA) framework and in their simplest form are a set of economic accounts that record the sales and purchases of industries within an economy for a given year. This includes the sales and purchases between industries, as well as sales to sources of final demand (households, government, exports etc), imports, compensation to employees, gross value added and taxes.

Core to the three methods – HEMs, standard IO modelling and CGE models – is the symmetric Industry by Industry (Ixl) table. IO tables for Northern Ireland are produced by NISRAⁱⁱ and are currently designated “experimental” to reflect their on-going evaluation.

What is the Hypothetical Extraction Method?

Hypothetical Extraction Method (HEM) has a long history in empirical IO analysis, and uses the interconnectedness between sectors to quantify the economic importance of an individual sector or groups of sectors by hypothetically shutting down its production.

As an example, for two sectors of otherwise identical economic characteristics, the sector which has “lower” connectedness to the economy (as measured through its linkages with other sectors) would generate smaller knock-on effects from being shut down.

Three key terms are used to classify the impacts. Below we consider these impacts from the perspective of employment, however the understanding is similar for other indicators such as output and GVA.

- **Direct effects** relate to the labour used by firms within the extracted sector;
- **Indirect effects** relate to the labour supported in firms that are within the domestic supply chain of firms in the extracted sector;
- **Induced effects** relate to the labour supported by the wage spending on goods and services in the economy of those employed directly in the extracted sector and indirectly in the extracted sector’s domestic supply chains.

A HEM does not have to be used to extract a whole sector. It can be used to understand the importance of a sub-sector (e.g. construction of buildings only, rather than all construction), a set of activities spanning sectors (e.g. renewable activities) or a company (e.g. potential closure of a specific company).

A HEM can be used to answer many questions, such as:

- What is the impact of a shock to a specific sector? E.g. construction.
- What is the impact of a shock to a specific sub-sector? E.g. construction of buildings only.
- What would the impact be if a particular project had not taken place? E.g. specific Government spending.
- What is the impact of a particular firm shutting, and this production permanently being replaced by imports?
- Which sectors have the strongest linkages with other sectors? Which have the strongest domestic supply chains? Which are highly supportive of domestic employment?

In summary, the HEM is useful for examining the knock-on effects of demand shocks to sectors, sub-sectors, economic activities or companies. These can be completely or partially extracted.

The FAI HEM for Northern Ireland currently provides results, by sector, in terms of full-time equivalent employment, Gross Value Added (GVA) and Output. However this can be extended to include further indicators such as:

- Which sectors, when including their supply chains, are associated with the most emissions?
- Which sectors, when including their supply chains, are associated with the most water use?
- Which sectors, when including their supply chains, support highly qualified / less qualified employment?
- To what extent do different sectors, when including their supply chains, support employment in different occupation groups?

How does it work?

In simple terms, HEM refers to the extraction of the purchases and sales made by a sector or group of sectors from the model of the economy, with a resulting reduction in economic activity.

Once the sector is extracted, the gross output of the new "hypothetical" economy will be smaller both due to the loss of the extracted sector, but also its purchases from or sales to the remaining sectors, and the resulting loss of forward and backward linkages elsewhere in the economy.

A summary of the method is as follows:

1. The sector(s) to be extracted are identified.
2. The sector's purchases from and sales to the remaining sectors are removed.
3. The sector's sales to sources of final demand (households, central government, local government, exports etc) are removed.
4. The size of the hypothetical economy, with the sector extracted, is estimated using the new structure.
5. The difference in the size of the economy initially and the size of the hypothetical economy provides the total impact on output.
6. Given the modelled change in output by sector, estimates can be produced for the change in employment, GVA or other indicators using *variable*-output coefficients. Similar to standard IO modelling, there are results for direct, indirect and induced effects.

Applying shocks

To perform a basic shock, the percentage of each sector's output to be extracted is specified. A sector can therefore be fully extracted by specifying 100% in the corresponding element in the shock vector. Multiple shocks can be input at the same time, and a partial shock of between 0% and 100% can also be performed.

These shocks can be informed by official data such as business data, GDP, employment data and so on.

There may also be cases where you wish to extract a clearly defined part of a sector from its parent sector. For instance, this could be a sub-sector, e.g. extracting all pharmaceutical research and development, but keeping the remaining research and development sector as is. This could also be a particular company.

IO methodologies by default assume that everything within a sector has the same characteristics as the overall sector. Therefore, if you wish to extract a clearly defined part of a sector (e.g. a sub-sector or a firm) from its parent sector in the IO, and the sub-sector represents 20% of the parent sector's output, a basic shock in a HEM assumes that sub-sector also directly employs 20% of the overall sector's employment, it makes 20% of the parent sector's purchases from and sales to other sectors, and these purchases and sales have exactly the same pattern as the overall sector and so on.

If it is the case that additional information is known about the sub-sector to be extracted, these details can be used to improve the estimates. For instance, if the sub-sector makes up 20% of output, but 50% of employment, this can be specified in the HEM. And, if the pattern of purchases and sales of the sub-sector differs greatly from the parent sector, this pattern can be specified.

The Fraser of Allander Institute HEM for Northern Ireland

The FAI HEM for Northern Ireland enables standard shocks to be analysed at a 63 sector level. The full list of these sectors can be found in the annex. This model is based on NISRA's Input-Output tables for 2016ⁱⁱⁱ.

To do this, a negative demand shock of between 0% (not extracted) and 100% (fully extracted) is entered. The model presents estimates of the impact on output, GVA and employment. It also provides each of these by direct, indirect and induced effects.

To demonstrate the outputs of this model, the tables below show the estimates of a 10% negative shock to output for 12 sectors. These 12 sectors have been selected due to their size and to ensure variety. The 10% shocks have been applied individually to sectors, rather than all at once.

It should be noted that employment figures are presented as employment instead of jobs, with the difference being that one person can hold multiple jobs.

The employment figures are also given as full-time equivalents (FTEs). Where a person working full-time is one FTE, a person working half the hours of full-time is half an FTE etc. This ensures that the results provide a more consistent measure between sectors that have mostly full-time employment, and sectors that have a large amount of part-time employment.

Table 1: Impact of individual 10% shocks to 12 sectors on GVA in Northern Ireland

| SIC | Sector | GVA | | | | % of Economy |
|--------------|---|--------|----------|---------|-------------|--------------|
| | | Direct | Indirect | Induced | Total | |
| 01 | Agriculture, hunting and related services | -52 | -59 | -41 | -153 | -0.4% |
| 10 | Food products | -90 | -136 | -131 | -357 | -0.9% |
| 30 | Other transport equipment | -45 | -33 | -54 | -132 | -0.3% |
| 41-43 | Construction | -259 | -193 | -216 | -668 | -1.7% |
| 47 | Retail trade services, except of motor vehicles and motorcycles | -278 | -56 | -165 | -498 | -1.3% |
| 56 | Food and beverage serving services | -74 | -26 | -56 | -155 | -0.4% |
| 62 | Computer programming, consultancy and related services | -71 | -8 | -61 | -140 | -0.4% |
| 64-66 | Financial and insurance services | -152 | -70 | -111 | -333 | -0.9% |
| 84 | Public administration and defence services; compulsory social security services | -333 | -76 | -239 | -648 | -1.7% |
| 85 | Education services | -238 | -42 | -223 | -503 | -1.3% |
| 86 | Human health services | -291 | -115 | -292 | -698 | -1.8% |
| 87-88 | Residential Care & Social Work Activities without accommodation | -103 | -21 | -73 | -198 | -0.5% |

Note: Rows may not sum to total due to rounding.

Table 2: Impact of individual 10% shocks to 12 sectors on FTE Employment in Northern Ireland

| SIC | Sector | FTE Employment | | | | % of Economy |
|--------------|---|----------------|----------|---------|----------------|--------------|
| | | Direct | Indirect | Induced | Total | |
| 01 | Agriculture, hunting and related services | -2,650 | -1,750 | -750 | -5,150 | -0.7% |
| 10 | Food products | -1,800 | -3,950 | -2,450 | -8,200 | -1.1% |
| 30 | Other transport equipment | -800 | -600 | -1,000 | -2,450 | -0.3% |
| 41-43 | Construction | -5,600 | -3,850 | -4,000 | -13,450 | -1.8% |
| 47 | Retail trade services, except of motor vehicles and motorcycles | -6,700 | -1,050 | -3,050 | -10,800 | -1.4% |
| 56 | Food and beverage serving services | -3,000 | -500 | -1,050 | -4,500 | -0.6% |
| 62 | Computer programming, consultancy and related services | -1,150 | -160 | -1,150 | -2,450 | -0.3% |
| 64-66 | Financial and insurance services | -1,750 | -1,450 | -2,100 | -5,300 | -0.7% |
| 84 | Public administration and defence services; compulsory social security services | -5,050 | -1,600 | -4,450 | -11,100 | -1.5% |
| 85 | Education services | -5,650 | -1,000 | -4,150 | -10,800 | -1.4% |
| 86 | Human health services | -6,150 | -2,600 | -5,400 | -14,200 | -1.9% |
| 87-88 | Residential Care & Social Work Activities without accommodation | -4,500 | -650 | -1,350 | -6,550 | -0.9% |

Note: Rows may not sum to total due to rounding. Rounded to the nearest 50.

Table 2 shows that the direct impact of a 10% fall in Construction output results in 5,600 FTE employments at risk.

This fall leads to Construction firms reducing the purchases from their supply chain. This indirect effect leaves a further 3,850 FTE employment in the supply chain at risk. Finally, the wage spending of the combined 9,450 FTE employment also supports economic activity in Northern Ireland. If this employment is lost, the activity associated with wage spending is also lost and so this induced effect leaves an additional 4,000 FTE employment at risk.

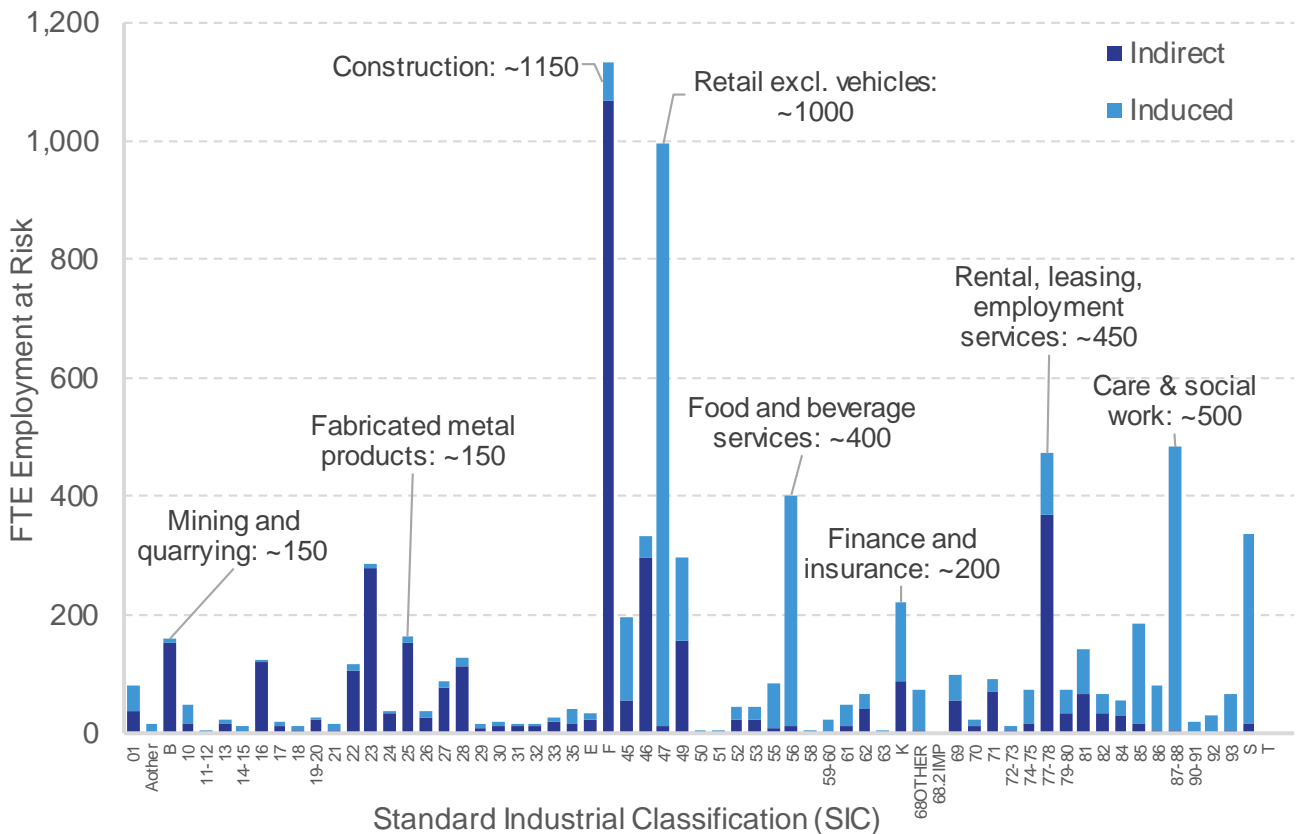
In total, a 10% fall in Construction output places 13,450 FTE employment across Northern Ireland’s economy at risk.

Figure 1 looks at the distributional impact of the FTE employment at risk for the spill-over impacts, i.e. the indirect and induced impacts combined. The sector with the most FTE employment at risk due to spill-over impacts is the Construction sector itself. This is not unusual as many construction firms purchase goods and services from other construction firms.

Several other sectors also see large indirect impacts on their employment. Looking at manufacturing, the minerals and fabricated metals sectors are particularly impacted. Out of services, wholesale services, land transport and rental, leasing & employment services sectors are also significantly impacted.

The induced impacts are concentrated on services sectors such as retail, food & beverage services, care & social work and other services. This is unsurprising as induced impacts match consumer spending patterns.

Figure 1: Distribution of the spill-over (indirect and induced) impacts on FTE employment in each sector resulting from a 10% fall in Construction output



Note: The full description of sectors is listed in the Annex. Labels rounded to the nearest 50.

What are the assumptions and how might they impact on the results?

There is no doubt that HEM is a useful modelling tool, but like all modelling frameworks it does have limitations. It shares several of the limitations with standard IO modelling.

Limitations of HEM and IO methods can be summarised as:

- Fixed technical coefficients, including a fixed relationship between output and other variables of interest (employment, GVA etc.);
- Entirely passive supply side, and thus no price response which would typically temper falls and increases;
- They are static, looking at a single point in time. The economy changes dramatically over time, which should be kept in mind for long term impacts;
- They are unable to determine effects which persist long after the impact is over, such as the impact of a different level of capital stock. These are termed the “legacy” effects.

Standard IO analysis may be interpreted as a special case of a CGE model, with fixed coefficients and a passive supply side.

The HEM does have some additional assumptions. Primarily that the loss of the sales of the extracted sector to other sectors, which the other sectors use as inputs for their own production, is not compensated by substitution from other non-extracted sectors. It also assumes that the loss of purchases of the extracted sector from other sectors is also not compensated by substitution from other non-extracted sectors. This means that the remaining sectors do not change their production methods to use different, domestically produced inputs.

The interpretation is that other sectors which purchased the products of the extracted sector to use as their inputs for their own production still purchase these products. However, instead of purchasing these from the extracted sector, they now entirely source these as imports from other countries.

Further Extensions

There are a number of ways that the FAI HEM for Northern Ireland can be extended to be of further use to policy making.

First, while IO tables take several years to produce due to the data requirements, with the latest IO table for Northern Ireland relating to 2016, it would be possible to bring forward or even ‘nowcast’ the table using National Accounts.

Second, the model can be used to examine the impact of economic shocks on a number of further indicators. These can include the impact of employment by gender, by qualifications, by full-time/part-time status, by employee/self-employed, by occupation and so on.

Third, the features of the model can be enhanced to more easily allow for more detailed shocks to be performed when specific information is known. For instance, if the loss of a large firm is being modelled and it is known that the pattern of purchases of the firm differ from the sector as a whole.

Fourth, development of more granular IO tables would enable analysis of more detailed sectors. The shocks applied would therefore be more 'relevant' to the industry. More granular tables could also look at specific business characteristics. If, within a given sector, firms were separated into groups, the impact on these groups could be analysed. Such groupings could include the size of firms, export status, ownership status and so on.

Fifth, data that is already available and could be useful for modelling different scenarios could be collected and identified, so that the time taken to model scenarios is reduced. For example, this could include consumer spending data that could be used to examine the impact of a shock to consumer spending. Or export data that can be used to model the impact of a shock to Northern Ireland's exports.

Conclusions

The FAI HEM for Northern Ireland provides a way to understand the economy-wide effects of negative demand shocks. This model is a useful part of a policymaker's toolkit when trying to understand how an impact on one sector can pass through to other sectors.

There are clear use cases for this model, particularly with the closure of specific sectors in 2020. Understanding how sectors are interrelated, and how this can impact on employment, is vital to ensuring any policy response is comprehensive.

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Sectors included in the FAI HEM for Northern Ireland

| SIC | Sector description |
|----------------|---|
| 01 | Products of agriculture, hunting and related services |
| Aother | Products of forestry and fishing |
| B | Mining and quarrying products |
| 10 | Food products |
| 11-12 | Beverages and tobacco products |
| 13 | Textiles |
| 14-15 | Wearing apparel and leather products |
| 16 | Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials |
| 17 | Paper and paper products |
| 18 | Printing and recording services |
| 19-20 | Coke, refined petroleum and chemicals |
| 21 | Basic pharmaceutical products and pharmaceutical preparations |
| 22 | Rubber and plastic products |
| 23 | Other non-metallic mineral products |
| 24 | Basic metals |
| 25 | Fabricated metal products |
| 26 | Computer, electronic and optical products |
| 27 | Electrical equipment |
| 28 | Machinery and equipment n.e.c. |
| 29 | Motor vehicles, trailers and semi-trailers |
| 30 | Other transport equipment |
| 31 | Furniture |
| 32 | Other manufactured goods |
| 33 | Repair and installation of machinery and equipment |
| 35 | Electricity transmission & distribution, gas distribution, steam & air conditioning distribution supply |
| E | Water supply; sewerage and waste management |
| F | Construction |
| 45 | Wholesale and retail trade and repair services of motor vehicles and motorcycles |
| 46 | Wholesale trade services, except of motor vehicles and motorcycles |
| 47 | Retail trade services, except of motor vehicles and motorcycles |
| 49 | Land transport |
| 50 | Water transport services |
| 51 | Air transport services |
| 52 | Warehousing and support services for transportation |
| 53 | Postal and courier services |
| 55 | Accommodation services |
| 56 | Food and beverage serving services |
| 58 | Publishing activities |
| 59-60 | Motion Picture, Video & TV Programme Production, Sound Recording & Music Publishing Activities & Programming & Broadcasting |
| 61 | Telecommunications services |
| 62 | Computer programming, consultancy and related services |
| 63 | Information services |
| K | Financial and insurance services |
| 68OTHER | Real estate activities (excluding imputed rent) |
| 68.2IMP | Imputed Rent |
| 69 | Legal and accounting services |
| 70 | Head offices and management consultancy |
| 71 | Architectural and engineering services |
| 72-73 | Scientific research and development, and advertising and research services |
| 74-75 | Other professional, scientific and technical services and veterinary services |
| 77-78 | Rental and leasing and employment services |
| 79-80 | Travel agency, tour operator & other reservation services & related services & security & investigation services |
| 81 | Services to buildings and landscape |
| 82 | Office administrative, office support and other business support services |
| 84 | Public administration and defence services; compulsory social security services |
| 85 | Education services |
| 86 | Human health services |
| 87-88 | Residential Care & Social Work Activities without accommodation |
| 90-91 | Creative, arts & entertainment services and libraries, archives, museums and other cultural services |
| 92 | Gambling and betting services |
| 93 | Sports services and amusement and recreation services |
| S | Other service activities |
| T | Services of households as employers of domestic personnel |

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- i [The Direct Long-term Trade Impacts of EU Exit Scenarios on Northern Ireland](#)
 - ii [NISRA - The Analytical Input-Output tables](#)
 - iii [NISRA - NI Economic Accounts Project - 2015 and 2016 Experimental Results](#)