# The Economic Impact of the Irish Bio-Economy


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# The Bio-Economy Input-Output Model: Development and Uses

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September 24th 2015

# CONTENTS

## 1.1 TABLE OF CONTENTS

## 1.2 List of Tables

## 1.3 LIST OF FIGURES

## 1.4 Author Details

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## EXECUTIVE SUMMARY

Given Ireland's bio-economy based natural resource strengths, in terms of its soils and oceans in particular, a number of economic strategies have been developed to maximise the contribution of Agricultural and Marine sectors to the economy. Consequently, it is desirable to understand the interactions between these sectors and the wider economy and to assess the potential impact of the outcomes of expansion strategies. This report describes the development of the Bio-Economy Input Output model (BIO) which can be used to analyse these linkages between the bio-economy sectors and the wider economy. This work represents the first attempt to model the Bio Economy as a whole, incorporating economic activity originating from both agricultural and marine resources.

Input-Output modelling is a linear modelling approach which involves the examination of the economic cycle of production by analysing the relative relationship between the flow of production inputs and resultant flow/destination of produced outputs in an economy. This report describes the basic modern framework of the Input-Output modelling approach, outlining the technical characteristics, data requirements, format development and structure in the creation of the Supply, Use and Symmetric Input-Output tables from the National Accounts. It also considers a number of key methodological choices in terms of production assumptions and balancing approaches.

The Symmetric Input-Output table summarises the source of inputs (columns) and the destination of outputs (rows) for all production sectors of the economy providing a means to study the intensity and direction of relationships between production sectors. This enables researchers to capture the relative importance of the different factors of production used by each sector and the resulting trade balance (Miller & Blair 2009). This information can then be used to calculate the Leontief Inverse Matrix. The construction of the Leontief Inverse Matrix facilitates the performance of a number of different types of multiplier analyses with respect to output, gross value added and employment. It enables researchers to capture the relative importance of the different factors of production used by each sector through the performance of multiplier analysis and provides a means of estimating and differentiating the full impacts, both direct and indirect, of sectoral expansion in the face of potentially competing resources.

Two major development strategies have been developed in recent years to develop the Agri-Food and Ocean Economy sectors in Ireland. The Food Wise 2025 strategy, a bottom up industry led strategic exercise by the 2025 Agri-Food Strategy Committee, building upon earlier Agrivision and Food Harvest documents, sets out a strategic plan for the development of the Agri-Food sector for the current period to 2025. The long-term vision as set out in the report is of 'Local Roots Global Reach' based on the continued development of the sector where efficient and environmentally-friendly production delivers sustainable export growth on global markets. The Harnessing our Ocean Wealth strategy, developed by the Inter-Departmental Marine Coordination Group in 2012, sets out aims and objectives to aid the development of the ocean economy in the future. The vision of the report is that "Our ocean wealth will be a key element of our economic recovery and sustainable growth, generating benefits for all our citizens, supported by coherent policy, planning and regulation, and managed in an integrated manner".

Given the importance of these sectors nationally and given the economic resources expended in their development, it is important to undertake policy impact assessment of their implementation. A series of scenario analyses are performed on both the Food Wise 2025 and Harnessing Our Ocean Wealth targets.

Due to the fact that bio-economic sectors locate much of their inputs in Ireland and because they employ relatively more people per unit of output, when these sectors increase their sales and in particular their exports, they generate a greater impact on the economy. Of the 162,000 jobs in the bio-economy in 2010, there were an additional 45,000 jobs elsewhere in the value chain. As much of the bio-economy is located in rural areas, this impact can play a particularly strong impact on rural job creation.

The report contains 4 analytical studies utilising BIO.

- The impact of reaching Food Wise 2025 growth scenarios
- The impact of reaching Harnessing our Ocean Wealth 2020 targets
- The impact of investment resulting from dairy expansion
- The impact of an expansion in the aquaculture sector

*Food Wise 2025*

In analysing Ireland's agriculture and food production sectors, Riordan (2012) estimated that the Agri-Food sector contributes almost 40% of net foreign earnings relative to 19% of exports due to a relatively low import requirement per unit of output, a low share of international ownership and repatriation of profits and a high local multiplier. Given the level of embeddedness of the Agri-Food sector within the Irish economy, targeted output growth will have significant impacts on Ireland's economic performance. The objective of BIO is to understand this embeddedness.

The Food Wise 2025 (FW2025) strategy sets out ambitious growth objectives for the Irish Agri-Food Sector which include,

- Increasing the value of Agri-Food exports by 85% to €19 billion.
- Increasing value added in the Agri-Food, fisheries and wood products sector by 70% to in excess of €13 billion.
- Increasing the value of Primary Production by 65% to almost €10 billion

Given that the focus of FW2025 strategy is on growth in value terms rather than on production, the FW2025 committee sub-groups did not attempt to translate the ambitions for each sector into specific headline quantitative production targets numbers when framing the strategy in contrast with previous strategies. However, in recognition of the need to inform a robust environmental analysis and to model potential job creation potential, the FW2025 sub-groups, with the assistance of selected sectoral experts, initially considered two alternative scenarios as to how each sector might progress in terms of output and growth, towards 2025. These two growth scenarios form the basis for the Input-Output analyses outline in Chapter 5 and Chapter 7.

It should be noted however that these growth scenarios were formulated prior to the adoption of the agreed strategic approach which focused on growth in value terms rather than production and were not endorsed by the Food Wise Strategy Committee. The scenarios were intended to represent a best estimate of how the various sectors might develop in the period to 2025. The "Base Case" scenario involves continuation of the rate of changes in production levels seen over recent years to generate a moderate increase in output through improvements in technology and management techniques. This scenario represented a business as usual rate of development for the Agri-Food industry. The “Base Case +” scenario represented more ambitious levels of expansion than recent historical trends given the recent pace of technological advances, the proposed investment in knowledge transfer under the RDP 2014-2020 and, particularly, the removal of milk quotas in March 2015.

In our analysis we modelled the main dairy, seafood and meat based growth scenarios as most of the employment increases will be felt through expansion in these sectors. Applying the output growth scenarios to the Bio-economy Input-Output Model (BIO), we generate the impact on output in the primary, processing and wider value chain sectors.[1]

We then apply employment elasticities to these output totals to generate an estimate of the number of jobs per sector resulting from the achievement of the growth scenarios. It should be noted however that the employment multiplier is quite sensitive to the choice of methodology. As a result we have chosen a more conservative estimate than the traditional average elasticity method. We choose a mid-point estimate between the upper bound and an alternative lower bound, drawing upon the peer reviewed estimates of the relationship between employment and output from Miller et al., (2014) published in the *Irish Journal of Agriculture and Food*.

Using this assumption, we estimate new jobs that result from reaching these growth scenarios of 23,000. There is a proportionally bigger impact elsewhere in the value chain, outside the farm gate. Within the primary sector most of the employment growth is generated in the dairy sector, which has relatively little under-employment. Additional employment is generated within the feed sectors as a result of the significant marginal elasticity. About a 45% of the total employment would be generated at the processing scale.

*Harnessing Our Ocean Wealth*

The total economic impact of reaching Harnessing Our Ocean Wealth (HOOW) targets results in an estimated direct impact of €3.3bn on the 2010 base year with an additional indirect effect of €2.7bn million in the wider economy, giving a total impact of over €9bn.

In terms of GVA, results show an estimated direct impact of €1.24bn of GVA on the 2010 base year and an indirect effect of €1.23bn in the wider economy, resulting in a total impact of €2.4bn in additional GVA. With regard to employment, the Bio-economy Input-Output model estimates the creation of 16,953 indirect jobs. The total employment impact of reaching HOOW targets would result in an additional 32,885 jobs.

*Dairy Expansion*

To illustrate the potential future applications of the Bio-Economy Input-Output model, more sector specific questions in relation to the investment impact of dairy sector expansion and the effects of a large expansion in the aquaculture sector have been investigated.

Growth in agriculture is fuelled by investment. This could be manifested in increased human capital embodied in the farm operator which can be acquired through education, training, experience and extension. It can also come in the form of improvements in the genetic merit of animals, improved crop varieties and better quality machinery and buildings. Finally investment can also come in the form of additional buildings, machines, livestock and land,

[1] Although this model is still at an early stage of development, all the validation indicators are positive, comparing very closely to early work done for Food Harvest 2020 using different data and methods.

commonly referred to as fixed investment. Chapter 7 focuses on the latter category of farm investment and provides an estimate of the potential economic impact, both upstream and downstream from the farm as a result of reaching growth scenarios suggested by the Food Wise 2025 committee for the dairy sector in particular.

With regard to dairy sector expansion, under a Base Case + scenario considered, a €2.2bn investment leverages €5.3bn euro in output, with €3.8bn in domestic output growth. 45% of output generated is in the construction sector, 28% in the Agri-Food sector, 17% in Services and 10% in Industry.

*Finfish Aquaculture Investment*

The rapidly rising demand for marine food products cannot be satisfied sustainably by wild fish stocks. Given the higher rates of consumption of seafood in areas in the world with high population growth, the global demand for seafood is expected to increase dramatically. To meet the expected increase in global seafood demand, aquaculture is rapidly emerging as an alternative to commercial fishing. Nearly half of the global fish demand and 20% of European consumption was met by the aquaculture industry in 2011 (European Commission, 2013) and this proportion is rising. However, while aquaculture alleviates pressure on wild fish stocks, it can have negative effect on its direct environment through demand for fish feed, the intensive use of treatments; and the introduction of waste products to the environment. On a global scale, aquaculture has been shown to decrease pressure on wild fish stocks but the environmental impacts can be substantial and should be included in any cost benefit analysis.

According to figures from SEMRU's latest 'Irish Ocean Economy Report' (SEMRU, 2015) Ireland produced 36,200 tonnes of farmed product in total in 2012 and there were 279 operations engaged in the sector during that period, of which the majority is engaged in shellfish aquaculture, producing 22,700 tonnes, whilst other marine species account for 12,400 tonnes of production. The report also highlights the turnover generated by marine aquaculture in 2012 was €130 million. Total GVA generated was €61 million. Turnover increased between 2010 and 2012 by 6%, with a 31% increase in GVA in the same period. Employment in the aquaculture sector was 956 FTEs in 2012, which shows an increase of just 0.4% with respect to 2010.

Recent plans for expansion in the Irish aquaculture sector have centred on expansion in finfish production. For finfish aquaculture an increase in output of €105m on 2010 output is simulated. With an output multiplier of 1.41 for the aquaculture sector based on the newly disaggregated Bio-Economy Input-Output model, a direct and indirect effect of €148 million per annum in the wider economy is estimated. When the seafood processing sector is included a further impact of €231m is estimated giving a total economic impact of €379m.

# Chapter 1. INTRODUCTION[2]

Cathal O’Donoghue and Eoin Grealis

## 1.1 INTRODUCTION

Given Ireland’s Bio-Economy based natural resource strengths, in terms of its soils and oceans in particular, the country, coming out of economic crisis has developed a number of economic strategies to maximise the contribution of these sectors to the economy. It is important in making decisions in these areas to understand the interactions between these sectors and the wider economy and to assess the potential impact of the outcomes of these strategies on the economy.

In this volume we describe the development of a type of model that can be used to analyse these linkages between the Bio-Economy and the wider economy; specifically, an Input-Output model. We call the model BIO (Bio-Economy Input-Output) model.

While the Input-Output approach has previously been applied separately to both the Agricultural (Miller et. al, 2014) and the Marine (Morrissey & O’Donoghue 2013) sectors, this work represents the first attempt to model the Bio-Economy as a whole, incorporating economic activity originating from both agricultural and marine resources.

*Definition of Bio-Economy*

There are varying definitions of the Bio-Economy used from science based biotechnology related industries to the wider renewable resource based industries. Research such as Riordan (2012) focuses on sectors relating to the agriculture and food sectors. For the purposes of this report, we focus on two major segments of the Irish economy, based upon agriculture and food based production and the wider sectors dependent upon the ocean.

The most recent statistics from the Central Statistics Office (CSO) indicate that the Agri-Food sector contributed about 6% of total value added in the economy and comprised about 7.5% of employment. The sector generates an operating surplus of approximately €2billion annually from a total goods output of almost €7billion. The beef sector is the most important component of the Agri-Food sector accounting for almost one-third of output, while the dairy sector accounts for almost a quarter. The vast majority of this output is destined for the export market. The wider Bio-Economy sector, which includes the beverage, infant milk formula sectors and food ingredients sectors, is a major source of net export earnings accounting for about 19% of exports in 2008, compared with 10% for the Agri-Food sector, (Riordan, 2012).

In addition to its importance to exports, Riordan (2012) estimates that the Bio-Economy contributed almost 40% of net foreign earnings amounted in 2008. In terms of Balance of International Payments flows, in 2008 every €100 of exports from the Bio-Economy generated €52 in net foreign earnings. In contrast, exports from non-bio sectors contributed only €19 in net foreign earnings for every €100 of exports. The main reasons for this disproportionately large contribution to net foreign earnings include; a relatively low import

[2] This research is part funded through the Beaufort Marine Research Award, which is carried out under the Sea Change Strategy and the Strategy for Science Technology and Innovation (2006-2013), with the support of the Marine Institute, funded under the Marine Research Sub-Programme of the National Development Plan 2007–2013. It is also funded by the Teagasc research programme, under the National Development Plan 2007–2013.

requirements per unit of output, a low share of international ownership and repatriation of profits, a high local multiplier and a significant inflow of funds from the EU in the form of subsidies and payments.

For the purposes of this report, the Ocean Economy Report produced by the Socio-Economic Marine Research Unit (SEMRU) in NUI Galway (Vega et al., 2015) defines the ocean economy as any economic activity that directly or indirectly uses the sea as an input – sea-specific activity – as well as any economic activity that produces an input or uses an output from a sea-specific activity in their production process.

Looking separately at the established and emerging marine sectors, it is reported that the Established Marine Industries in 2012 had a turnover of €3.96 billion, providing employment to 16,271 FTEs representing 95% of the total turnover and 93% of total employment in Ireland's ocean economy. They defined this sector as shipping and maritime transport, marine tourism and leisure, international cruise, sea fisheries, marine aquaculture, seafood processing, oil and gas exploration and production, marine manufacturing and marine retail services.

The report noted that the "marine retail services, sea fisheries and seafood processing, all experienced a significant increase in activity", with turnover, Gross Value Added (GVA) and employment increasing across the sector in the period. The aquaculture sector also exhibited increases, albeit of a smaller scale, across all three variables. While the shipping and maritime sector experienced a significant increase in turnover coupled with a smaller increase in GVA during the period, employment fell during the same period. Marine manufacturing also experienced an increase in turnover and employment, accompanied by a fall in GVA. Marine tourism experienced a fall in turnover, GVA and employment during the period. However the year 2012 proved to be a turning point for the marine tourism sector and tourism in general, with positive growth in the sector in succeeding periods, 2013 and 2014.

The Emerging Marine Industries in 2012 had a turnover of €215 million and provided employment to 1,154 FTEs representing 5% of the turnover and 7% of employment in Ireland's ocean economy. Emerging industries refer to those that are still at a relatively early stage of development or growth, and are primarily R&D intensive and/or use the latest cutting edge technology in their pursuit of economic growth. Ireland's ocean economy includes a number of emerging industries with considerable growth potential. It includes high tech marine products and services, marine commerce, marine biotechnology and bio-products and marine renewable energy.

*Sectoral Strategies*

Two major development strategies have been developed in recent years to develop the Agri-Food and Ocean Economy sectors in Ireland.

The Food Wise 2025 strategy, a bottom up industry led strategic exercise by the 2025 Agri Food Strategy Committee, building upon earlier Agrivision and Food Harvest documents, sets out a strategic plan for the development of Agri-Food sector for the current period to 2025. The long-term vision as set out in the Report is of 'Local Roots Global Reach' based on the continued development of the sector where efficient and environmentally-friendly production delivers sustainable export growth on global markets. The strategy sets out a series of 350 measures to achieve sustainable growth with the aim of:

- Increasing the value of Agri-Food exports by 85% to €19 billion.

- Increasing value added in the Agri-Food, fisheries and wood products sector by 70% to in excess of €13 billion.
- Increasing the value of Primary Production by 65% to almost €10 billion
- The creation of an additional 23,000 direct jobs in the Agri-Food sector all along the supply chain from primary production to high valued added product development.

The Harnessing our Ocean Wealth strategy, developed by the Inter-Departmental Marine Coordination Group (MCG) in 2012, sets out aims and objectives to aid the development of the ocean economy in the future. The vision of the report is that "Our ocean wealth will be a key element of our economic recovery and sustainable growth, generating benefits for all our citizens, supported by coherent policy, planning and regulation, and managed in an integrated manner."

Three high-level goals, of equal importance, based on the concept of sustainable development have been developed:

- Goal 1 focuses on a thriving maritime economy, whereby Ireland harnesses the market opportunities to achieve economic recovery and socially inclusive, sustainable growth.
- Goal 2 sets out to achieve healthy ecosystems that provide monetary and non-monetary goods and services (e.g. food, climate, health and well-being).
- Goal 3 aims to increase our engagement with the sea. Building on our rich maritime heritage, our goal is to strengthen our maritime identity and increase our awareness of the value (market and non-market), opportunities and social benefits of engaging with the sea.

The report identifies two high level targets

- Double the value of our ocean wealth to 2.4% of GDP by 2030.
- Increase the turnover from our ocean economy to exceed €6.4bn by 2020

*Input-Output Model*

Given the importance of these sectors nationally and given the economic resources expended in their development, it is important to undertake policy impact assessment of their implementation. In this report we identify the linkages between the sectors referenced in these strategies.

A particular technique used in economic impact assessment is the use of Input-Output Models. These models are statistical descriptions of the interdependencies between different sectors in the economy, reflecting the flow of resources between different inputs and uses for these sectors. The CSO in Ireland produces a regular Input-Output table for Ireland. The 2010 CSO Input-Output table contains 58 sectors. The generation of an Input-Output table requires a significant number of data resources. Many of these resources are collated from different sources and thus may not all be collected with the same purpose or definition. It is therefore a significant challenge to make the data consistent. The table should be viewed therefore as a best estimate rather than as purely a statistical summary.

In the CSO report, the primary resource sectors, Agriculture, Forestry and Fisheries are grouped together in one sector, as are the Food Processing industries. Conversely, the non-seafood based Marine sectors are grouped with their individual parent industrial classification. Utilising data collected by Teagasc in their National Farm Survey and marine sectoral information produced by NUI Galway's SEMRU in their Ocean Economy report, together with CSO Census of Industrial Production (CIP), we attempt to decompose these sectors into a finer sectoral resolution analysis.

This report is based upon a collaborative research project between Teagasc, NUI Galway in association with the Marine Institute and funded Beaufort Marine Research Award and the Teagasc Research Programme. It is develops a piece of research infrastructure that may be of use to analysts attempting to understand the flows and interactions between and within the Bio-Economy sectors

This work builds upon earlier work focusing on the Agri-Food sector by O'Toole and Matthews, 2002a, 2002b) and Miller et al. (2014) that respectively developed Agri-Food Input-Output Models based upon the 1993 and 2005 years respectively. Morrissey and O'Donoghue (2013) also developed an earlier marine sector focused Input-Output table. In this work we undertake a number of additions

- Adapt the most recent CSO Input-Output Table for Ireland 2010
- Expand the Agricultural and Marine Sectors, making them consistent with the accounting flows and characteristics of the Teagasc National Farm Survey and the SEMRU Ocean Economy Report Series
- Systematise the development of the model to make it easier to replicate in the future

### 1.2 Overview of the Report

The purpose of this report is to describe the development of BIO, the Bio-Economy Input-Output Model. It does purport to be a manual on input-output modelling. Midmore (1991) contains a comprehensive discussion in relation to developing input-output models in relation to the agricultural sector, which contains more detailed discussions about the methodological choices.

In Chapter 2, we describe the methodological context for what we are doing. It describes the development of a Leontief Inverse Matrix from Supply and Use Tables. Chapters 3 and 4 describe the data sources used and assumptions made to disaggregate respectively the Food, Forestry and the Marine sectors. The resulting Input-Output tables are published in the Appendix to this report.

We then utilise the Input-Output model to undertake a number of economic impact assessments. In Chapter 5, two potential growth scenarios[3] provided by the Food Wise 2025

[3] Given that the focus of Food Wise 2025 Strategy on growth in value terms rather than production, the FW2025 committee sub-groups did not attempt to translate the ambitions for each sector into specific headline quantitative production targets numbers when framing the Strategy. However, in recognition of the need to inform a robust Environmental Analysis and to model potential job creation potential the FW2025 sub-groups, with the assistance of selected sectoral experts, initially considered two alternative scenarios as to how each sector might progress in terms of output and growth, towards 2025. These scenarios were formulated prior to the adoption of the agreed strategic approach which focused on growth in value terms rather than production, were not endorsed by the Food Wise Strategy Committee, and were intended to represent a best estimate of how the various sectors might develop in the period to 2025.

The two scenarios were: "Base Case"; and "Base Case +". Base Case involves continuation of the rate of changes in production levels seen over recent years to generate a moderate increase in output through improvements in technology and management techniques. This scenario essentially represented a "business as usual" development of the Agri-Food industry. The Base Case + Scenario represented more ambitious levels of expansion than recent historical trends given the recent pace of technological advances, the proposed investment in knowledge transfer under the RDP 2014-2020 and, particularly, the removal of milk quotas in March 2015.

(FW2025) Committee are used to model the direct and indirect output and employment impacts. In Chapter 6, we perform a similar analysis to consider the impact of achieving the Harnessing our Ocean Wealth targets.

Delivering on the Food Wise growth projections will include a requirement for specific farm level investments. In Chapter 7, we consider the output implications of delivering investment specifically required to achieve dairy expansion. In Chapter 8, we dig more deeply into one of the objectives of the Food Wise 2025 strategy, to examine the implications of Aquaculture investments.

### 1.3 FUTURE DIRECTIONS

The focus in developing this model was to develop a systematic approach to producing a Bio-Economy sector Input-Output model, using recent CSO Input-Output tables. However there are a number of methodological improvements that are possible and necessary.

The most urgent improvement necessary is to improve the quality of the forestry component of the model. The report draws upon older data contained in Ni Dhubhain et al., (2009). It is hoped to collect a survey of forestry primary and secondary businesses in near future to improve our understanding of inputs and outputs of the sector.

One of the uses stakeholders require from the model is to use the model for employment impacts of policy reforms. Later in the report, we consider differences between average and marginal multipliers. We also note quite large differences in results depending upon the choice of methodology and data. We also currently do not have a marginal analysis for the Marine sectors given a lack of data. Given the interest in this use, it merits a more detailed study in relation to the relationship between output and employment.

One of the purposes for which the model was developed was to be able to describe value chains for use in Life-Cycle Analysis of Greenhouse Gas emissions. The authors are currently funded to extend some of the sustainability indicators used in Food sectors to consider farm to fork emissions.

Since the economic crisis, given the differential impact on rural areas, there has been a growing interest in the spatial impact of policy; see for example, the Commission for the Economic Development of Rural Areas report and the Regional Jobs strategies. In order to say more about the spatial impact of economic changes, Teagasc has collected a number of surveys identifying the spatial impact of production and consumption decisions. A current PhD project funded by Teagasc is examining the capacity to disaggregate impact analysis across space.

An Input-Output model tracks the flow of activities between sectors and final demand uses. However there is also interest in understanding the flow of resources such as labour and capital income or taxes and transfers across the economy. Miller at al. (2011a) developed an Agri-Food Social Accounting Matrix (SAM) for Ireland using 2005 which captures these flows. The data requirements are more challenging. See also Ferrari and Boulanger (2014). Depending upon resource ability the systematisation involved in this project could potentially be extended to update the Agri-Food SAM more often.

Input-Output models and SAMs are static models. They track resource flows and prices through an economy. However they do not incorporate behavioural response to price or income changes. A Computable General Equilibrium (CGE) model extends a SAM to incorporate behavioural changes. Boysen et al., (2014) and Miller et al. (2011b) developed Agri-Food CGE models. Again however, the ability to update these models is resource dependent.

Lastly, Eurostat has developed Agri-Food Social Account Matrices for Agricultural sectors (Müller et al., 2009) utilising Farm Accountancy Data Network (FADN) data. While the Teagasc National Farm Survey Data is part of the FADN, it contains more disaggregated data, allowing for a more detailed disaggregation. Work is necessary to compare and contrast the different methods. It would also be useful to utilise the models for comparative greenhouse gas emission comparisons. At present a similar comparative approach has not taken place for the Marine sectors. However with increasing interest at the European level on the blue economy there are opportunities to undertake comparative work in this area.

# Chapter 2. METHODOLOGICAL APPROACH: INPUT-OUTPUT MODELLING

Eoin Grealis and Cathal O'Donoghue

## 2.1 INTRODUCTION

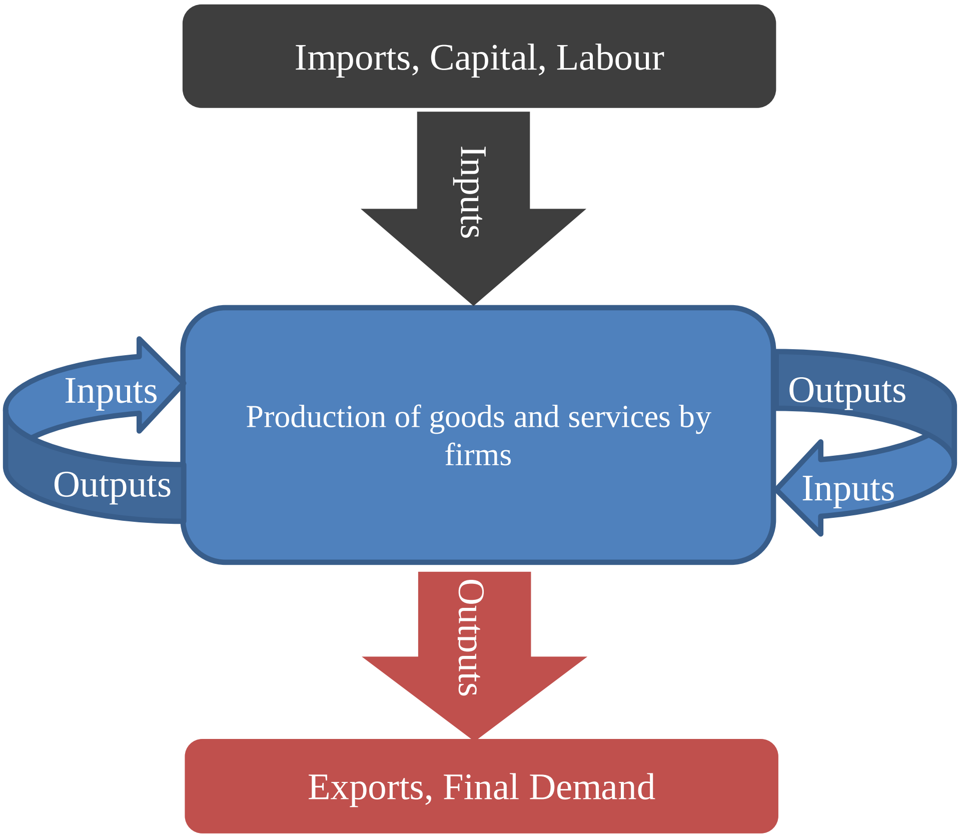
Input-Output Modelling is a linear modelling approach which involves the examination of the economic cycle of production by analysing the relative relationship between the flow of production inputs and resultant flow/destination of produced outputs in an economy. Developed by Wassily Leontief in the 1930s, Input-Output Modelling provides an analytical framework within which the interdependence of industries can be studied. It consists of a system of linear equations, each one of which describes the distribution of an industry's product throughout the economy (Millar & Blair 2009). The underlying principals and assumptions of the Input-Output approach form the basis of many different types of economic analysis and is one of the most widely used applied methods in Economics (Baumol, 2000). The creation of a symmetric Input-Output table for the purposes of economic analysis has become an integral part of the system of national accounts both at European (ESA, 1995) and global level (SNA, 1993) with over 80 countries publishing Supply, Use and Input Output tables by 2001 (Guo 2002). Input-Output Modelling has been used extensively to identify the relative structural importance or embeddedness of individual economic sectors to the wider economy. It can be used to simulate the direct and indirect impacts associated with changes in levels of output on many economic indicators such as national level output, employment, GVA and the balance of trade.

This chapter describes the basic modern framework of the Input-Output modelling approach, outlining the technical characteristics, data requirements, format development and structure in the creation of the Supply, Use and Symmetric I-O tables from the National Accounts. It also considers a number of key methodological choices in terms of production assumptions and balancing approaches.

## 2.2 INPUT-OUTPUT MODELLING

Input-Output modelling conceptualises the production economy as a highly connected system of interdependent processes (Leontief, 1973). In order to produce the vast range of goods and services available in the modern economy, many different combinations of inputs are required. These are then subjected to a diverse set of processing systems. However, the inputs required to produce a particular product are themselves the product outputs of other distinct processing systems. The production economy is thus viewed as a cyclical system of product flows where inputs and outputs are continually consumed and produced. At its most basic level, Input-Output Modelling attempts to capture this structural interdependency, tracing the input requirements for each product back through the production cycle.

**Figure 2.1 Input-Output Framework for the Production Economy**




Symmetrically, it also tracks the destination or flow of products outputs to be used as inputs in other areas of the economy. This framework is then expanded to account for factors of production, the consumption of final demand and the balance of trade. The basic framework of the Input Output approach to modelling the production economy is illustrated in Figure 2.1. The production of goods and services by firms constantly requires outputs from other firms as inputs in their production processes before the final product is made. This is termed intermediate consumption since it is consumed in the production of another product rather than by final demand. In addition to product inputs, inputs in the form of labour, capital and imports are required and may be viewed as injections or additions to the total output estimated for the production cycle. Conversely, the export of finished products and consumption by Final demand (households, governments, non-profit sectors) may be viewed as leakages from the production cycle.

In this way, it is possible to view the production of a particular product not only in terms of its interdependency with all other products but also in terms of its total value to the domestic economy. Ceteris paribus, an increase in output of any product will necessarily trigger an increase in demand for those products used in its intermediate consumption. An increase in output from production processes whose intermediate consumption is heavily reliant on domestically produced goods creates a greater "knock on" impact in the domestic production economy than an increase in production of a good whose production process relies heavily on imported goods.

However this is only one measure of the economic impact of an exogenous increase in demand. Input-Output modelling facilitates the estimation of knock on effects for a number of different economic indicators including output, employment, GVA and household income. The estimation of these effects can be termed as multiplier analysis. The concept of the multiplier rests upon the difference between the initial effect of an exogenous change and the total effects of that change enabling the calculation of the “indirect” effect (Millar & Blair 2009). The use of multiplier analysis enables policy makers with limited resources to target the expansion of production in those sectors of the economy from which the greatest combined benefits (in terms of both direct and indirect effects) may accrue.

The performance of Input-Output analysis for an entire economy is a complex task which requires significant resources. It requires the availability of large amounts of observable data on the quantities and nature of product imports, exports, household consumption levels, labour, capital consumption and formation. It also requires information on the input mix of each product’s intermediate consumption. However, in a modern economy there are an almost innumerable number of differentiable products and production processes. As such to perform an Input-Output multiplier analysis on each individual product at a macroeconomic level would be impractical. To facilitate meaningful analysis, all products are necessarily aggregated to a broader sectoral category with quantities measured over a standardised period. As such traditional Input-Output modelling presents a static or “snapshot” analysis of inter-sectoral relationships at a fixed point in time.

The next section describes the Supply, Use and Input Tables and the creation of the Leontief inverse matrix from which the output multipliers for each sector are created.

### 2.3 Supply, Use and Input-Output Tables

Supply, Use and Input-Output tables describe the flow of transactions of goods and services in the economy over a fixed period of time (typically a year). They provide a detailed picture of the total quantity of goods and services supplied by domestic industries and the total quantity of products used in their manufacture. They also provide information on the compensation of factors of production, consumption by final demand and the balance of trade. The construction of the Supply and Use (SUT) tables is seen as key step towards balancing the three independent estimates of GDP (production, income and expenditure) derived from the national accounts (Eurostat 1995). It is from the SUT tables that the final symmetric Input-Output table is constructed.

*Supply Table*

The supply table describes the total quantity and type of goods and services supplied by industries. Due to the wide range of goods and services produced in a modern economy a certain amount of aggregation is necessary in order to provide a coherent structure. Products are classified according to the CPA (Classification of Products by Activity) method with the industrial activities that produced them classified by their assigned NACE (European Classification of Economic Activities) code. While the CPA and NACE codes are fully aligned, the distinction is required in order to report secondary output. While each firm is assigned a NACE code on the basis of the classification of its primary produced output, many firms produce multiple secondary products some of which may not match its NACE code classification. For example, at a micro unit level a farm holding may diversify its enterprise by providing tourist accommodation. Alternatively, at a larger scale, a multinational corporation may have a diverse portfolio of manufactured goods and services.

A condensed version of the 58 sector 2010 Supply table for Ireland is shown in Table 2.1 which shows the supply table at basic prices for the primary, manufacturing and services sectors. By definition, each NACE industry supplies the largest share of its matching CPA products which can be observed in the diagonal entries in columns 1-3. The fourth column describes the total supply of Primary, Manufacturing and Service products at basic prices, i.e. the price the producer receives for its products. The addition of imports, margin, taxes and subsidies in the fifth column provide the total supply of Primary, Manufacturing and Service goods in the economy at purchaser's prices, i.e. the price the final consumer pays for the product in the final column with total output by industry display in the final row.

**Table 2.1 Condensed 2010 Supply Table at Basic Prices €m**

| | *NACE* | 1-9 | 10-43 | 45-97 | | | |
|---|---|---|---|---|---|---|---|
| | *Industries €m* | Primary | Manufacturing | Services | Total domestic Supply and Basic Price | Imports, Margins, Taxes and Subsidies | Total supply at purchasers' prices |
| *CPA* | *Products* | | | | | | |
| 1-9 | Primary | **7,175** | 94 | - | 7,269 | 5,446 | 12,715 |
| 10-43 | Manufacturing | 338 | **109,979** | 14 | 110,332 | 79,925 | 190,257 |
| 45-97 | Services | 41 | 1,400 | **217,349** | 218,790 | 57,986 | 276,776 |
| | Total output by industry | 7,554 | 111,474 | 217,363 | 336,391 | 143,356 | 479,747 |

*source CSO (2014)

*Use Table*

The use table describes the total quantity and type of goods and services used by each industry to produce their products and by final demand which includes households, governments, Non-profit organisations, exports, the formation of capital and changes in the stock of inventories. The figures are reported at purchaser's prices, i.e. the final price paid for each good by the ultimate consumer, i.e., after taxes, subsidies and trade margins have been applied. A condensed version of the 58 sector use table at purchaser's prices for Ireland for 2010 is shown in Table 2.2 which shows use at purchaser's prices for the Primary, Manufacturing and Services sectors. Products from the Manufacturing sector represent the largest share of inputs used by the Primary and Manufacturing industries with the largest share of inputs used in the services consisting of services products. The fourth column describes the total use of Primary, Manufacturing and Service products at purchaser's prices with use by Final demand detailed in the fifth column. The final column provides the total use of Primary, Manufacturing and Service products in the economy at purchaser's prices.

**Table 2.2 Condensed 2010 Use Table at Purchaser's Prices €m**

| | *NACE* | 1-9 | 10-43 | 45-97 | | | |
|---|---|---|---|---|---|---|---|
| | *Industries* | Primary Production | Manufacturing | Services | Total Inter-Industry | Final Demand | Total Uses at Purchasers Prices |
| *CPA* | *Products €m* | | | | | | |
| 1-9 | Primary Production | 1,437 | 7,560 | 246 | 9,243 | 3,471 | 12,715 |
| 10-43 | Manufacturing | **2,763** | **34,495** | 17,097 | 54,355 | 135,902 | 190,257 |
| 45-97 | Services | 644 | 32,143 | **96,940** | 129,726 | 147,049 | 276,776 |
| | Total intermediate consumption | 4,844 | 74,198 | 114,283 | 193,325 | 286,423 | 479,747 |
| | GVA at basic prices | 2,711 | 37,276 | 103,080 | 143,066 | | |
| | Output at basic prices | 7,554 | 111,474 | 217,363 | 336,391 | | |

*source CSO (2014)

The total supply of each product in the last column of Table 2.1 is equal to the total use of the product in Table 2.2. Similarly, the total output of each industry in the last row of the Table 2.1 is equal to the sum of the intermediate consumption and GVA at basic prices of that industry, which is the last row of Table 2.2

*Input-Output Table*

The Input-Output table is a balanced product by product table outlining the inter-sectoral relationships present in the production system. It is derived from the Supply and Use tables. The transformation is based on the commodity technology assumption4 which is outlined in the Handbook of Input-Output Table Compilation and Analysis (United Nations, 1999). The structure of the Input-Output table is similar to the Use table but contains some key differences. Table 2.3 shows a three sector condensed version of Ireland's 2010 Symmetric Input-Output Table of Domestic Product Flows.

[4] The commodity technology assumption (CTA) is one of two types of assumptions which may be used in converting supply and use tables into symmetric input-output tables. It assumes that a product has the same input structure in whichever industry it is produced. An alternative method is to assume that all commodities made by an industry share the same input structure which is known as the Industry Technology Assumption (ITA). A detailed discussion of the merits of both approaches is provided by Guo et. al, (2002).

**Table 2.3 2010 Symmetric Input-Output Table of Domestic Product Flows €m**

| | *CPA* | 1-9 | 10-43 | 45-97 | | | |
|---|---|---|---|---|---|---|---|
| | *Products* | Primary | Manufacturing | Services | Total Inter-Industry | Final Demand | Total Output |
| *CPA* | *Products €m* | | | | | | |
| 1-9 | Primary Production | 1,079 | 3,685 | 156 | 4,920 | 2,350 | 7,269 |
| 10-43 | Manufacturing | 602 | 8,164 | 5,014 | 13,780 | 96,552 | 110,332 |
| 45-97 | Services | 646 | 10,088 | 56,828 | 67,563 | 151,227 | 218,790 |
| | Total intermediate consumption | 2,328 | 21,937 | 61,998 | 86,263 | 250,129 | 336,391 |
| | Imports | 2,247 | 51,366 | 49,329 | 102,942 | 25,384 | 128,326 |
| | Product taxes less subsidies | 51 | 336 | 3,734 | 4,120 | 10,910 | 15,030 |
| | GVA | 2,645 | 36,693 | 103,729 | 143,066 | 286,423 | 479,747 |
| | Total Inputs | 7,269 | 110,332 | 218,790 | 336,391 | | |

*source CSO (2014)

The table summarises the use of products in the production of other products and those products are valued at basic prices since they are used as intermediate consumption in the production process and do not represent the price paid by the final consumer. Information on the imports of goods and services for further production and for final consumption is included followed by rows detailing product taxes less subsidies and GVA giving the total domestic output for each sector. In addition, the table is symmetric. The sum of the entries row for Primary, Manufacturing and Service products is equal to the sum of the entries in the corresponding column. This is because total output of a product, shown at the end of a row, can be analysed into various costs going into its production, shown down the column[5]. These column sums and row sums are equal to the total domestic supply column of Table 2.1.

It should be noted that while the Input-Output table is balanced and its values are largely consistent with the National Income and Expenditure accounts it is not possible to achieve full agreement across all data sources which contribute to the national accounts with the result that certain inconsistencies will arise. These inconsistencies may occur due to slightly different interpretations in terminology; such as in definition of the gross output where freight and trade margins are included in that value in the supply table yet are not included in the CIP definition. Other differences may occur as a result of individual accounting practices, mismatched product classifications or simply conflicting values collected across different censuses and surveys. The input-output table should therefore be viewed as a best estimate of the balanced interdependent relationship of product flows within the economy rather than as an absolute or definitive statement of nominal values.

[5] See explanatory background notes on the 2010 Supply, Use and Input-Output Tables from the CSO available at http://www.cso.ie/en/releasesandpublications/ep/p-sauio/supplyanduseandinput-outputtablesforireland2010/

## 2.4 LEONTIEF INVERSE MATRIX

The Symmetric Input-Output table summarises the source of inputs (columns) and the destination of outputs (rows) for all production sectors of the economy providing a means to study the intensity and direction of relationships between production sectors. This enables researchers to capture the relative importance of the different factors of production used by each sector and the resulting trade balance (Miller & Blair 2009). This information can then be used to calculate the Input-Output table's Leontief Inverse Matrix which is defined as:

$$Leontief = (I\text{-}A)^{-1} \text{ where:}$$

$$A = a_{ij} = \frac{z_{ij}}{x_{ij}} = \text{matrix of input coefficients for sectors } i\text{-}j$$

$$z_{ij} = \text{intermediate demand for inputs between sector } i \text{ and the supply sector } j$$

$$x_{ij} = \text{total output for sector } i$$

The Leontief Inverse Matrix enables an estimation of individual sectoral multipliers, capturing both the direct and indirect macroeconomic effects of potential increases or decrease in exogenous demand (Leontief, 1974). The construction of the Leontief Inverse Matrix facilitates the performance of a number of different types of multiplier analyses with respect to output, GVA and employment.

*Output Multiplier*

Output multipliers measure the combined effects of the direct and indirect consequences of a change in final demand and can be readily calculated from the Leontief Inverse Matrix. An output multiplier for sector *j* is defined as the total value of production in all sectors of the economy that is necessary in order to satisfy one euro worth of final demand for sector *j*'s output (Miller & Blair 2009). Table 2.4 describes the 2010 Leontief Inverse Matrix for Domestic Product Flows at a condensed three sector level. The final row reports the output multipliers for the Primary, Manufacturing and Services sectors which are the column sums of the Leontief elements for the Domestic Product Flow table.

**Table 2.4 2010 Leontief Inverse Matrix for Domestic Product Flows**

| | *CPA Products* | 1-9 | 10-43 | 45-97 |
|---|---|---|---|---|
| | | Primary | Manufacturing | Services |
| *CPA* | *Products* | | | |
| 1-9 | Primary | 1.18 | 0.04 | 0.00 |
| 10-43 | Manufacturing | 0.11 | 1.09 | 0.03 |
| 45-97 | Services | 0.16 | 0.14 | 1.36 |
| | Output Multiplier | 1.44 | 1.27 | 1.39 |

*source CSO (2014)

*Gross Value Added Multiplier*

The GVA multiplier relates the new value added created in each sector in response to the initial exogenous demand shock. The GVA multiplier is defined as:

$$GVA\_Mult = GVA\ (I\text{-}A)^{-1} \text{ where:}$$

$$GVA = \text{vector of sectoral value added coefficients}$$

$$(I\text{-}A)^{-1} = \text{the Leontief Inverse Matrix}$$

Miller & Blair (2009) note that it is often argued that value added is a better measure of a sector's contribution to an economy than total output as it captures the value that is added by the sector in engaging in production i.e. the difference between a sector's total output and the cost of its intermediate inputs.

*Employment Multiplier*

This employment multiplier is the ratio of direct plus indirect employment changes to the direct employment change. As with the GVA multiplier, the employment multiplier is calculated in a similar fashion and is defined as:

$$Emp\_Mult = E\ (I\text{-}A)^{-1} \text{ where:}$$

$$E = \text{vector of employment coefficients}$$

$$(I\text{-}A)^{-1} = \text{the Leontief Inverse Matrix}$$

It should be noted that the type of employment co-efficient chosen can have a significant impact on results. The most basic employment multiplier uses average employment coefficients based on a direct jobs/euro output ratio. However, it is unlikely in the case of large scale expansion that such ratios will be maintained. Economies of scale will likely be experienced as well as increases in productivity. The estimation of employment multipliers based on marginal employment co-efficients would be a more preferable approach. This is subject however, to the availability and consistency of measurement of sufficient data on prices and the determinants of output over a significant time period.

### 2.5 SUMMARY

Input-Output analysis is a widely used methodology within economics that measures inter-sectoral flows within the production system. Symmetric Input-Output tables summarise the source of inputs (columns) and the destination of outputs (rows) for all production sectors of the economy providing a means to study the intensity and direction of relationships between production sectors. It enables researchers to capture the relative importance of the different factors of production used by each sector through the performance of multiplier analysis and provides a means of estimating and differentiating the full impacts, both direct and indirect, of sectoral expansion in the face of potentially competing resources.

# Chapter 3. INPUT-OUTPUT MODEL – AGRICULTURE, FISHERIES, FORESTRY AND FOOD

Cathal O'Donoghue, Eoin Grealis, John Lennon,

## 3.1 INTRODUCTION

The objective of this chapter is to outline the development of the Agri-Food component of the Bio-Economy Input-Output Model. This work builds upon earlier work by O'Toole and Matthews, 2002a, 2002b) and Miller et al. (2014) that respectively developed Agri-Food Input-Output Models based upon the 1993 and 2005 years respectively. In this work we undertake a number of additions

- Adapt the most recent 2010 CSO Input-Output Model for Ireland 2010
- Expand the Agricultural Sectors, making more consistent with the accounting flows and characteristics of the Teagasc National Farm Survey
- Systematise the Development of the Model to make it Easier to Replicate in Future

## 3.2 PRIMARY FOOD SECTORS

In the CSO Input-Output Table for 2010, primary production is grouped into Agriculture, Forestry and Fisheries. Specifically we divide sectors into the following sub-sectors

- Agriculture into the main Animals and Crop sub-sectors
- Sea fishing and Aquaculture
- Forestry

While the disaggregation of the Sea fishing and Aquaculture is explained in the following chapter, the following section describes the decomposition of the Agriculture and Forestry sectors into its disaggregated components.

## 3.3 AGRICULTURE

The main source of data for the Agricultural Sector is the Teagasc National Farm Survey. This dataset is the Irish component of the Farm Accountancy Data Network (FADN) and is the gold standard for economic data in relation to Agriculture in Ireland. Collected annually over a 40 year period, data has been collected on about 1000-1200 farms. Information is collected for the main land based agricultural systems, but has only partial information for the pig and poultry sectors.

Of particular relevance to our work is the fact the NFS decomposes inputs and outputs at the enterprise level. Irish Agriculture contains mainly pastoral animal systems, where farms will have at least one animal enterprise, together with enterprises the produce animal feed. Dairy systems will contain both a dairy enterprise and a cattle enterprise for non-milking animals. The beef industry is a very important sector in Ireland, with about 90% of farms in the NFS for example having some form of cattle system. Many tillage only farms will have multiple crop enterprises. In this model, we utilise this information to track inputs and outputs.

*Structure of Data*

The objective of the data structure in the NFS is to collect data so that a measure known as family farm income can be calculated. Family Farm Income is defined as Market Gross

Output plus Farm Subsidies minus Direct Costs minus Overhead Costs. Market Gross Output, some Enterprise Specific Subsidies and Direct Costs can be allocated to the enterprise level.

Crop information in the NFS is stored at multiple levels

- Year
- Farm Code
- Crop Code

In other words, crop inputs are stored only for crops that exist on the farm. There are 66 different types of crop recorded in the NFS.

The collected information is stored in a number of different tables:

- Labour Input
- Crop Output, Uses (Feed x Animal Type, Sales, Seed, Waste, Closing Balance, Home Use)
- Fertilizer
- Expenses (Seed, Crop Protection, Transport Cost, Machinery Hire)
- Disposal of Feed stuff

In addition for the fertiliser table, there is another layer as different types of fertiliser are recorded

These files are combined together, so that direct costs and output can be identified in one file for one period for each crop type. Fertiliser usage is not identified separately in the direct costs, but combined together.

There is a time period issue with the data. Some crop volume is in the current year with the remainder used in the following year and so counts as a closing balance. Some of the crops used then for the following year then comes from the opening balance.

For cash crops, the value of output is the market price, while for non-cash fodder crops, the value of the output relates to the cost of production. Thus the price for opening balances and crops used in the current year may have different prices. As a result, an extension of earlier models is to separate crops into opening balance based crop usage and current year harvested crops.

Crops are allocated by use, whether as feed, seed, sales, home use, waste or into the closing balance for the year. Crops that are fed to animals are further allocated to the animal enterprise (dairy, cattle, sheep, goats, deer, horses, poultry, pigs, etc.). We can thus identify the amount in terms of both volume and value (based upon calculated unit costs) of each crop type by animal enterprise.

As we record the inputs of each crop that is used in the current year and because the dataset is a panel dataset and so we record the inputs of crops that enter this year’s account in the opening balance, we can track the input use such as fertiliser used in silage fed to sheep. However this can cause time period problems as fertiliser can be bought time period 1, stored as a closing balance and used in period 2 as an input into a crop that is harvested in period 3, stored and part of an opening balance in year 4 and fed to an animal in that year. Thus in this case, a price change in fertiliser may have an impact on an animal based direct 3 years later.[6]

Each animal system also contains other non-feed input costs which are allocated to each enterprise including:

- Veterinary and Medical
- Artificial Insemination
- Purchased Feed (Concentrate and Bulk)
- Miscellaneous Expenses
- Transportation
- Labour

In the NFS animal purchases are treated as a deduction from output rather than as an input cost. Changes in value as well as flows between cattle and dairy enterprises such as calves and heifers are also incorporated in the gross output.

Farm direct costs are calculated as the sum of animal and crop direct costs less inter-enterprise transfers such as milk fed to calves.

Crop market gross output includes crops sold outside the farm, but excludes fodder crops used on farm as an input into the animal enterprises, which are treated as costs. Dairy market gross output includes milk sales plus the value of calves and the net transfer between the cattle system. Other animal systems include sales minus purchases, net transfers with dairy and value changes in stock. Land rented out, home use; sales of other farm outputs like turf and contracting/rental of machinery are also included in market gross output at the farm level.

Market gross margin at either farm level or enterprise level can be defined as the market gross output minus direct costs, while gross margin (at both levels) is the market gross margin plus subsidies.

Overhead costs (including depreciation) are calculated at the farm level and subtracted from farm level gross margin to get the family farm income, and when subtracted from market gross margin gives us a measure known as the net margin.

*Preparation of Agricultural Inputs and Outputs*

In our model, we take the CSO Input-Output table as the primary source of our constraint data. While we take information from the national accounts and the National Farm Survey, we make any adjustments consistent with the macro totals in the CSO national accounts. In Table 3.1, we describe the allocation of output into domestic output and imports as well as exports. Due to balancing and definitional differences between the national accounts total for these sectors and the Input-Output totals. Total output in the Input-Output table is 1 per cent lower than the national accounts, while imports are 6 per cent higher. Exports are 27% higher.

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[6] This animal may potentially be sold two years later, meaning that in a life-cycle situation the price change may affect a life-cycle margin for 6 years. However in the NFS, we incorporate direct costs in specific years, with change in value of the animals being incorporated in the gross output for a particular year.

We use national accounts to source inputs by sector. Therefore we scale all national accounts sectors pro rata. We disaggregate cereals in Table 3.2 using National Farm Survey information with aggregated cereals, fruit and vegetable, forage and other crops sectors.

**Table 3.1 Output Adjustment to Ensure Consistency between National Acc. and Input-Output Table €m**

| | National Accounts | | | | Adjusted | | | |
|---|---|---|---|---|---|---|---|---|
| €m | Output | Domestic Output | Exports | Imports | Output | Domestic Output | Exports | Imports |
| Cattle | 1676 | 1502 | 339 | 173 | 1671 | 1488 | 247 | 183 |
| Pigs | 334 | 334 | | | 330 | 330 | | |
| Sheep | 166 | 166 | | | 164 | 164 | | |
| Horses | 151 | 151 | 73 | | 149 | 149 | 54 | |
| Poultry | 112 | 112 | | | 111 | 111 | | |
| Milk | 1542 | 1542 | | | 1527 | 1527 | | |
| Other Products | 41 | 41 | | | 40 | 40 | | |
| Cereals | 377 | 377 | | | 373 | 373 | | |
| Fruit & Veg | 1257 | 346 | 227 | 912 | 1308 | 342 | 166 | 966 |
| Forage | 701 | 701 | | | 694 | 694 | | |
| Other Crops | 102 | 102 | | | 101 | 101 | | |
| Seafood | 504 | 337 | 370 | 167 | 511 | 334 | 270 | 177 |
| Aquaculture | | | | | | | | |
| Forestry | 417 | 417 | 302 | | 413 | 413 | 220 | |
| Home Grown Seed | 19 | 19 | | | 19 | 19 | | |
| Contract Work | 278 | 278 | | | 275 | 275 | | |
| Total | 7676 | 6424 | 1312 | 1252 | 7688 | 6362 | 957 | 1326 |
| IO | 7688 | 6362 | 957 | 1326 | 7688 | 6362 | 957 | 1326 |
| Ratio NACC:IO | 1.00 | 1.01 | 1.37 | 0.94 | | | | |

Source: CSO Agricultural, National Accounts (2010)

**Table 3.2 Dividing Crops into Sub-Components**

| | | |
|---|---|---|
| Cereals | Concentrate Own | 0.93 |
| | Concentrate Opening | 0.07 |
| Forage | Pasture | 0.35 |
| | Winter Forage Own | 0.07 |
| | Silage own | 0.54 |
| | Hay Own | 0.04 |
| | Winter Forage Op | 0.00 |
| | Silage Op | 0.00 |
| | Hay Op | 0.00 |
| | Winter Forage Pur | 0.00 |

Source: Teagasc National Farm Survey (2010)

In Table 3.3, we describe the allocation of output by final use. We allocate a number of sectors as intra-agricultural flows including fodder, part of the cereals and the milk used as input into the cattle sector, taken from the NFS. Inputs into construction and the timber in the original CSO Input-Output table are assigned to the forestry sector. Except for the Food Processing sector, there are relatively few inter-industry inputs into other sectors, which are allocated in proportion to the total share of inter-industry outputs from that sector. The rest of the outputs from primary Agri-Food are allocated to the secondary processing sector.

In Table 3.4, we describe the sources of input into the Agriculture, Fisheries and Forestry Sector. Table 3.5 describes the allocation utilised for intermediate inputs from the primary agriculture sector to other sectors based upon the NFS. The first set of variables which describing the inputs come straight from the Primary and Secondary Food sectors. A number of variables are associated with one Input-Output sector. For the remainder, where there are NFS variables associated with a number of sectors, we allocate on a pro-rata basis. Some manual balancing is required based upon expert judgement.

**Table 3.3 Allocation of Primary Output by Final Use (2010) €m**

| | Output (Agri-Food) | Output (Processing) | Output (Wood Processing) | Output (Construction) | Output Other | Total inter-industry | Final consumption | Gross fixed capital formation | Change in inventories | Exports f.o.b. (free on board) | Total Final uses €m |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cattle | 0.0 | 1336.1 | 0.0 | 0.0 | 0.0 | 1336.1 | 0.0 | -11.1 | 99.0 | 247.0 | 1671.0 |
| Pigs | 0.0 | 294.2 | 0.0 | 0.0 | 14.3 | 308.5 | 0.0 | -2.8 | 25.0 | 0.0 | 330.0 |
| Sheep | 0.0 | 146.0 | 0.0 | 0.0 | 7.1 | 153.1 | 0.0 | -1.4 | 12.0 | 0.0 | 164.0 |
| Horses | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 92.0 | -2.0 | 6.0 | 54.0 | 149.0 |
| Poultry | 0.0 | 73.9 | 0.0 | 0.0 | 3.6 | 77.5 | 26.2 | -0.9 | 8.0 | 0.0 | 111.0 |
| Milk | 42.8 | 1294.5 | 0.0 | 0.0 | 65.1 | 1402.4 | 0.0 | -12.7 | 137.0 | 0.0 | 1527.0 |
| Other Products | 0.0 | 36.0 | 0.0 | 0.0 | 1.8 | 37.7 | 0.0 | -0.3 | 3.0 | 0.0 | 40.0 |
| Cereals | 25.7 | 306.2 | 0.0 | 0.0 | 16.2 | 348.1 | 0.0 | -3.1 | 28.0 | 0.0 | 373.0 |
| Fruit & Veg | 0.0 | 274.1 | 0.0 | 0.0 | 13.3 | 287.4 | 786.7 | -8.5 | 76.0 | 166.0 | 1308.0 |
| Forage | 674.8 | 0.0 | 0.0 | 0.0 | 0.0 | 674.8 | 0.0 | -5.8 | 25.0 | 0.0 | 694.0 |
| Other Crops | 0.0 | 90.1 | 0.0 | 0.0 | 4.4 | 94.5 | 0.0 | 0.0 | 7.0 | 0.0 | 101.0 |
| Seafood | 11.1 | 172.9 | 0.0 | 0.0 | 9.0 | 192.9 | 38.7 | -1.1 | 10.0 | 270.0 | 511.0 |
| Aquaculture | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Forestry | 0.0 | 0.5 | 145.3 | 39.2 | 0.0 | 185.0 | 0.0 | -1.0 | 9.0 | 220.0 | 413.0 |
| Seed | 19.2 | 0.0 | 0.0 | 0.0 | 0.0 | 19.2 | 0.0 | 0.0 | 0.0 | 0.0 | 19.0 |
| Machinery Hire | 254.4 | 0.0 | 0.0 | 0.0 | 0.0 | 254.4 | 0.0 | 0.0 | 21.0 | 0.0 | 275.0 |
| Total | 1028.0 | 4024.4 | 145.3 | 39.2 | 134.7 | 5371.5 | 943.6 | -50.7 | 466.0 | 957.0 | 7688.0 |

**Table 3.4 Sources of Input from the Primary Agriculture, Fisheries and Forestry Sector (2010) €m**

| | Total intermediate consumption | Product taxes less subsidies | Total consumption at purchasers' prices | Value added | Total inputs (=Total domestic supply row in Table 1) | Imports (=Imports in Table 1) | Total (=Total domestic supply + imports in Table 1) |
|---|---|---|---|---|---|---|---|
| Cattle | 1027.0 | 10.1 | 1037.0 | 450.0 | 1487.0 | 183.0 | 1671.0 |
| Pigs | 228.0 | 2.2 | 230.0 | 100.0 | 330.0 | 0.0 | 330.0 |
| Sheep | 113.0 | 1.1 | 114.0 | 50.0 | 164.0 | 0.0 | 164.0 |
| Horses | 103.0 | 1.0 | 104.0 | 45.0 | 149.0 | 0.0 | 149.0 |
| Poultry | 77.0 | 0.8 | 77.0 | 34.0 | 111.0 | 0.0 | 111.0 |
| Milk | 1054.0 | 10.4 | 1065.0 | 462.0 | 1526.0 | 0.0 | 1526.0 |
| Other Products | 28.0 | 0.3 | 28.0 | 12.0 | 40.0 | 0.0 | 40.0 |
| Cereals | 257.0 | 2.5 | 260.0 | 113.0 | 373.0 | 0.0 | 373.0 |
| Fruit & Veg | 236.0 | 2.3 | 239.0 | 103.0 | 342.0 | 966.0 | 1308.0 |
| Forage | 479.0 | 4.7 | 484.0 | 210.0 | 694.0 | 0.0 | 694.0 |
| Other Crops | 70.0 | 0.7 | 71.0 | 31.0 | 101.0 | 0.0 | 101.0 |
| Seafood | 219.0 | 2.3 | 221.0 | 112.0 | 334.0 | 177.0 | 511.0 |
| Aquacultu re | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Forestry | 306.0 | 2.8 | 308.0 | 104.0 | 412.0 | 0.0 | 412.0 |
| Seed | 0.0 | 0.0 | 0.0 | 19.0 | 19.0 | 0.0 | 19.0 |
| Machinery Hire | 0.0 | 0.0 | 0.0 | 278.0 | 278.0 | 0.0 | 278.0 |
| Total | 4198.0 | 41.2 | 4240.0 | 2122.0 | 6362.0 | 1326.0 | 7688.0 |
| IO | 4198.0 | 41.2 | 4240.0 | 2122.0 | 6362.0 | 1326.0 | 7688.0 |

**Table 3.5 Linkage between NFS and Input-Output Headings used in disaggregating Agricultural Inputs**

| Input-Output Sector | NFS Variable |
|---|---|
| Agriculture, forestry and fishing | Pasture; Silage own; Hay Own; Silage Op; Hay Op; Winter Forage Pur; Dairy; Roots; Milk Quota Lease; Seed (Own); Machinery Hire |
| Food & beverages and tobacco products | Concentrate Own; Concentrate Opening; Winter Forage Own; Silage own; Winter Forage Op; AI; Misc Overheads; Concentrate Pur |
| NFS variables that span Input-Output Variables | |
| Vet and Medical | |
| Fertiliser | Chemicals and chemical products; Wholesale trade |
| Machinery Hire | Machinery and equipment n.e.c.; Motor vehicles, trailers and semi-trailers; Other transport equipment; |
| Misc DC | Textiles, wearing apparel and leather products; Wood and wood products (excl furniture); Pulp, paper and paper products; Printed matter and recorded media; Rubber and plastics; Water collection, treatment and supply; Sewerage, refuse and remediation services; Legal and accounting services; mgt consultancy; Architectural and engineering services; Scientific research and development services; Advertising and market research services; |
| Utilities | Petroleum; furniture; other manufacturing; Electricity and gas supply; Motor fuel and vehicle trade and repair; Postal and courier services; Telecommunications services |
| Interest | Financial intermediation services; Insurance, reinsurance and pension funding |
| Machinery Operating Expenses | Other non-metallic mineral products; Basic metals; Fabricated metal products; Computer, electronic & optical products; Electrical equipment; Repair/installation of machinery & equipment |
| Misc Overhead Costs | Accommodation and food & beverage services; Publishing, film and broadcasting services; Computer consultancy; data processing; Real estate services; Rental and leasing services; Employment services; Travel and tourism service activities; Security, office & business support services; Public administration ; Cultural and sporting services; Recreation services; Membership organisation services; Repair of consumer goods |
| Crop Protection | Chemicals and chemical products; Mining, quarrying and extraction |
| NFS sectors with a single Input-Output sector | |
| Transport | Land transport services |
| Seed (Pur) | Chemicals and chemical products |
| Building upkeep | Construction and construction works |

Given that we use the Teagasc National Farm Survey to disaggregate the National Accounts inputs by enterprise, it is important to understand systematic differences between the two datasets. In Table 3.6, we compare the CSO national accounts. Cattle and dairy totals are reasonably close, with CSO cattle total output report a figure 5 per cent higher than that derived from the NFS, reflecting the small farms that are not present in the NFS. However the NFS dairy output is 8 per cent higher than the national accounts. There is however a large difference between the sheep output in the NFS and the CSO national accounts. Reflecting the fact that the NFS sample does not cover the commercial pig and poultry farms and the horse producers that do not have other farm enterprises, output from these sectors are not comparable. It would be worth engaging in a wider dialogue between Teagasc and the National Farm Survey in relation to differences between the different sources of data.

**Table 3.6 Teagasc National Farm Survey vs CSO National Accounts Animal Output comparison (2010) €m**

| | CSO | NFS | Ratio |
|---|---|---|---|
| Dairy | 1541.9 | 1673.00 | 0.92 |
| Cattle | 1502.3 | 1437.00 | 1.05 |
| Sheep | 165.6 | 275.00 | 0.60 |
| Horses | 150.8 | 11.80 | 12.8 |
| Pigs | 333.7 | 24.60 | 13.6 |
| Poultry | 112.2 | 0.06 | 1898.3 |
| Deer and Goats | 40.8 | 0.00 | n/a |
| Total (Dairy, Cattle, Sheep) | 3209.8 | 3385.00 | 0.95 |

Source: Teagasc National Farm Survey (2010), CSO Agricultural, National Accounts (2010)
Note: Value of Calf and animals moved from Dairy to Cattle in NFS

**Table 3.7 Animal Inputs (2010)**

| | Own Feed (Curr) | Own Feed (OB) | Purchased Feed | Milk Substitution | Vet and Medical | AI | Transport | Misc | Labour | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Milk | 0.10 | 0.11 | 0.31 | 0.13 | 0.12 | 0.11 | 0.05 | 0.03 | 0.05 | 0.00 |
| Cattle | 0.11 | 0.09 | 0.26 | 0.15 | 0.12 | 0.13 | 0.02 | 0.03 | 0.07 | 0.02 |
| Sheep | 0.14 | 0.13 | 0.32 | 0.16 | 0.11 | 0.07 | 0.03 | 0.02 | 0.03 | 0.01 |
| Horses | 0.10 | 0.14 | 0.16 | 0.14 | 0.23 | 0.08 | 0.06 | 0.03 | 0.01 | 0.03 |
| Pigs | 0.00 | 0.06 | 0.80 | 0.01 | 0.05 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 |
| Poultry | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Deer and Goats | 0.14 | 0.13 | 0.32 | 0.16 | 0.11 | 0.07 | 0.03 | 0.02 | 0.03 | 0.01 |

Source: Teagasc National Farm Survey (2010)

**Table 3.8 Crop Inputs (2010)**

| | Fertiliser | Labour | Seed (HG) | Crop Protection | Seed (Pur) | Transport | Machinery Hire | Misc |
|---|---|---|---|---|---|---|---|---|
| Concentrate Own | 0.34 | 0.00 | 0.00 | 0.30 | 0.13 | 0.00 | 0.21 | 0.01 |
| Concentrate (OB) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Pasture | 0.73 | 0.00 | 0.00 | 0.04 | 0.05 | 0.00 | 0.18 | 0.00 |
| Winter Forage | 0.25 | 0.00 | 0.00 | 0.11 | 0.15 | 0.00 | 0.41 | 0.07 |
| Silage | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 | 0.08 |
| Hay | 0.50 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.47 | 0.03 |
| Winter Forage (OB) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 |
| Hay (OB) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 |
| Forestry | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.41 | 0.59 |
| Other Cash Crop | 0.27 | 0.00 | 0.00 | 0.16 | 0.19 | 0.00 | 0.37 | 0.01 |
| Potato, Fruit & Veg | 0.20 | 0.06 | 0.16 | 0.19 | 0.15 | 0.00 | 0.13 | 0.12 |
| Setaside | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 0.36 | 0.48 |
| Sugar Beet | 0.43 | 0.00 | 0.00 | 0.39 | 0.18 | 0.00 | 0.00 | 0.00 |
| Total | 0.41 | 0.01 | 0.02 | 0.09 | 0.06 | 0.00 | 0.36 | 0.05 |

Source: Teagasc National Farm Survey (2010)

*Forestry*

In developing the forestry component of the model, we draw upon work of colleagues in UCD and UCC who have heretofore undertaken a number of projects developing an Input-Output Model for Forestry (See Ni Dhubhain, 2009). In our model, we utilise the same coefficients for the Forestry Sector described in Table 3.9, using expert judgement, to disaggregate. It is planned in the near future to undertake a forestry industry economic survey to improve the structure of the Input-Output model for the forestry primary and processing sectors.

**Table 3.9 Distribution of Output by Source of Input in Forestry**

| | Share of Output |
|---|---|
| Intermediate Consumption | 0.21 |
| Wage and Salaries | 0.21 |
| Profits | 0.28 |
| Other Domestic Inputs | 0.03 |
| Imports | 0.26 |
| Total | 1.00 |

### 3.4 SECONDARY FOOD SECTORS

In disentangling the "Food & beverages and tobacco products" sector, we utilise the CIP, which provides, turnover, output, labour and cost information for the following sectors:

- Processing and preserving of meat and production of meat products
- Processing and preserving of fish, crustaceans and molluscs
- Processing and preserving of fruit and vegetables
- Manufacture of vegetable and animal oils and fats
- Manufacture of dairy products
- Manufacture of grain mill products, starches and starch products
- Manufacture of bakery and farinaceous products
- Manufacture of other food products
- Manufacture of prepared animal feeds
- Manufacture of beverages
- Manufacture of tobacco products

*Inputs*

The CSO Input-Output table contains more disaggregated information in relation to costs than the CIP. The latter contains information on

- Materials and fuels
- Industrial Services
- Non-industrial Services

In general, except for Agriculture, Forestry and Fisheries, we assume the same pattern of inputs within these categories. We allocate all Input-Output headings to the three categories, using the Wholesale trade variable as a balancing device.

In Table 3.11, we disaggregate total food and beverages into sub-sector components at the domestic level. We subtract imports for intermediate use (Imports less Goods for Resale) to get domestic output. In the input-output model, we further disaggregate the three input components using the same ratios as at the total sector level.

Utilising data, consistent with the primary food sectors in Table 3.12, we report the agriculture and fisheries inputs into the processing sector, while in Table 3.13, we report the food sector to food sector primary flows. Without further information, we make the assumption that this is diagonal with inputs from the same sector and without any inter-sub-sector flows. While this is a relatively strong assumption, it will have relatively minor qualitative impact upon the overall multipliers.

Table 3.14 describes the destinations of flows from the food processing sectors.

### Table 3.10 Structure of Inputs for Food and Beverages Sector (€m) (2010)

| | Intermediate Consumption (Domestic) | Materials and fuels | Industrial Services | Non-industrial Services | Stock changes during year - Materials and fuels | Intermediate Consumption | Imports | Imports for IC | Goods for resale without further processing |
|---|---|---|---|---|---|---|---|---|---|
| Food | 11410.0 | 8700.4 | 167.5 | 4597.6 | 33.1 | 13465.5 | 5077.7 | 2055.5 | 3022.2 |
| Beverages | 1206.3 | 882.2 | 32.8 | 586.6 | 56.6 | 0.0 | 547.3 | 295.3 | 252.0 |
| Total | 12616.2 | 9582.5 | 200.3 | 5184.1 | 89.7 | 13465.5 | 5624.9 | 2350.8 | 3274.1 |

Source: CIP (2010)

### Table 3.11 Allocation of Inputs across Disaggregated Food Sectors (Domestic) (€m)

| | Meat and meat products | Fish, crustaceans and molluscs | Fruit and vegetables | Vegetable, animal oils and fats | Dairy products | Grain mill products, starches and starch products | Bakery and farinaceous products | Other food products | Prepared animal feeds | Beverages | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Materials and fuels | 3181 | 241 | 85 | 13 | 2889 | 28 | 245 | 1198 | 739 | 847 | 9465 |
| Industrial Services | 38 | 8 | 4 | 1 | 52 | 3 | 15 | 34 | 11 | 34 | 198 |
| Non-industrial Services | 108 | 14 | 34 | 4 | 32 | 0 | 91 | 4255 | 29 | 562 | 5129 |
| Imports | 644 | 63 | 20 | 4 | 518 | 21 | 82 | 530 | 212 | 316 | 2409 |
| Domestic Intermediate Consumption | 3326 | 263 | 123 | 17 | 2973 | 30 | 351 | 5488 | 779 | 1443 | 14793 |

**Table 3.12 Inputs from the Primary Agriculture and Fisheries sector (€m)**

| | Meat and meat products | Fish, crustaceans and molluscs | Fruit and vegetables | Vegetable, animal oils and fats | Dairy products | Grain mill products, starches and starch products | Bakery and farinaceous products | Other food products | Prepared animal feeds | Beverages | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cattle | 1336 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1336 |
| Pigs | 294 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 294 |
| Sheep | 146 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 146 |
| Horses | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Poultry | 74 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 74 |
| Milk | 0 | 0 | 0 | 0 | 1295 | 0 | 0 | 0 | 0 | 0 | 1295 |
| Other | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 |
| Cereals | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 280 | 14 | 306 |
| Fruit & Veg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 274 | 0 | 0 | 274 |
| Forage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other Crops | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 90 | 0 | 0 | 90 |
| Seafood | 0 | 90 | 0 | 0 | 0 | 0 | 0 | 83 | 0 | 0 | 173 |
| Aquaculture | 0 | 173 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 173 |
| Forestry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Source: CIP (2010)

**Table 3.13 Food to Food Flows (€m)**

| | Meat and meat products | Fish, crustaceans and molluscs | Fruit and vegetables | Vegetable, animal oils and fats | Dairy products | Grain mill products, starches and starch products | Bakery and farinaceous products | Other food products | Prepared animal feeds | Beverages |
|---|---|---|---|---|---|---|---|---|---|---|
| Meat and meat products | 676 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fish, crustaceans and molluscs | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fruit and vegetables | 0 | 0 | 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Vegetable, animal oils and fats | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dairy products | 0 | 0 | 0 | 0 | 1042 | 0 | 0 | 0 | 0 | 0 |
| Grain mill products, starches and starch products | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 |
| Bakery and farinaceous products | 0 | 0 | 0 | 0 | 0 | 0 | 201 | 0 | 0 | 0 |
| Other food products | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 524 | 0 | 0 |
| Prepared animal feeds | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 319 | 0 |
| Beverages | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 679 |

Source: CIP (2010)

**Table 3.14 Destinations of Food and Beverage Sectors (€m)**

| | Agriculture, forestry and fishing | Food & beverages and tobacco products | Non-Food Inter-Industry | Inter Industry | Final consumption of h'holds, excl govt transfers | NPISH | Govt consumption plus transfers | Gross fixed capital formation | Exports | Output |
|---|---|---|---|---|---|---|---|---|---|---|
| Original IO | 1154 | 3533 | 2130 | 6816 | 1724 | -577 | 80 | 1 | 17680 | 25724 |
| Meat and meat products | 0 | 676 | 470 | 1146 | 361 | 98 | 17 | 0 | 2760 | 5379 |
| Fish, crustaceans and molluscs | 0 | 0 | 41 | 41 | 31 | -11 | 1 | 0 | 286 | 466 |
| Fruit and vegetables | 0 | 70 | 19 | 89 | 15 | -5 | 1 | 0 | 30 | 217 |
| Vegetable, animal oils and fats | 0 | 10 | 2 | 13 | 2 | -1 | 0 | 0 | 8 | 28 |
| Dairy products | 23 | 1042 | 417 | 1482 | 319 | 67 | 15 | 0 | 1890 | 4765 |
| Grain mill products, starches | 0 | 11 | 6 | 17 | 5 | -2 | 0 | 0 | 2 | 72 |
| Bakery and farinaceous products | 0 | 201 | 54 | 255 | 42 | -15 | 2 | 0 | 192 | 621 |
| Other food products | 0 | 524 | 901 | 1426 | 691 | -648 | 32 | 0 | 10478 | 10313 |
| Prepared animal feeds | 1131 | 319 | 0 | 1450 | 91 | 0 | 4 | 0 | 278 | 1358 |
| Beverages | 0 | 679 | 219 | 898 | 168 | -61 | 8 | 0 | 1756 | 2505 |
| Total | 1154 | 3533 | 2130 | 6816 | 1724 | -577 | 80 | 1 | 17680 | 25724 |

# Chapter 4. INPUT-OUTPUT MODEL – MARINE

Eoin Grealis, Cathal O'Donoghue

## 4.1 INTRODUCTION

This chapter describes the process by which 13 individual marine sub sectors are disaggregated from the 2010 Symmetric Input-Output Table to formulate the marine component of the Bio-Economy Input Output Model[7]. Information on output, intermediate consumption, GVA, imported inputs, exports, and employment are then gathered for each sub-sector from a variety of different data sources and are then used to generate the required additional rows and columns in the newly disaggregated Input-Output table. These new columns and rows form the basis for the calculation of the Leontief Inverse Matrix from which various the multiplier analyses for the marine sector can be performed.

In addition, the chapter also outlines a number of assumptions which are required in order to populate the rows and columns of new the additional marine sectors in the Input-Output table. These assumptions can be broadly summarised into two categories. Assumptions necessitated as a result of the unavailability of detailed data on the sources of inputs and the destination of outputs and assumptions which are required in order to balance the Bio-Economy Input Output Model.

## 4.2 DATA AND METHODOLOGICAL ASSUMPTIONS

The CSO supplies a number of data sets that provide information on turnover, GVA and employment for all production sectors in the Economy. This data is collected across a number of censuses and surveys. In many cases, data collection is largely concerned with production activity: net output/turnover, input, value added, and employment. However, there are a few data sets which provided information on the nature and volume of each industry's intermediate consumption, i.e. the composition of their inputs which is required in order to construct an Input-Output table. The CSO census and surveys which provide data on Ireland's marine sectors include the CIP, 2007-2012, the Annual Services Inquiry (ASI), 2007-2012, Building and Construction Inquiry (BCI), 2007- 2012 and Intrastat, 2007-2012. The data relating to marine activity from these censuses and surveys is provided at the NACE four-digit level. The NACE code system is a pan-European classification system that groups enterprises according to their business activities by assigning a unique 2, 3 and 4 digit code to each industry. Marine activities can be fully or partially marine activities. In the latter case, proxies are used to identify the percentage attributable to the marine sector in these activities (see Vega et al., (2015) for more details).

[7] In order to maintain consistency with SEMRU's established reporting structure an eight sector disaggregation was chosen.

Table 4.1 describes the Bio-Economy Input Output Marine Sectors, their NACE codes, their sub-sectors, where applicable and their primary data sources

**Table 4.1 Table of Bio-Economy Input Output Marine Sectors**

| **Sector** | **NACE Codes** | **Sub-Sector** | **Primary Data Sources** |
|---|---|---|---|
| Sea Fishing | 03.1 | Sea Fishing | BIM |
| Aquaculture | 03.2 | Aquaculture | BIM/SEMRU |
| Oil &Gas | 06.1, 8.12 & 09.9 | Oil &Gas | CIP |
| Seafood Processing | 10.2 | Seafood Processing | CIP |
| Marine Manufacturing Engineering and Construction | 30.1 | Marine Transport Equipment | CIP |
| | 33.15 | Marine Repair/Installation | CIP |
| | 42.91 | Marine Construction | BCI |
| | 71 | Marine Engineering | SEMRU |
| Marine Retail Trade | 47.23 | Marine Retail Trade | ASI/SEMRU |
| Marine Shipping and Transport | 50.1 & 50.2 | Marine Water Transport Services | ASI |
| | 52 | Marine Warehousing | ASI |
| | 77.34 | Marine Rental & Leasing Services | ASI |
| Marine Tourism | 55-56,79 | Marine Tourism | SEMRU/Fáilte Ireland |

*Key Assumptions*

It is assumed that each NACE disaggregated marine sector, only produces products that can be classified according to its matching CPA classification and that no other sector produces those products. This means that each marine sector can be disaggregated from its parent sector directly from the values displayed in the original Input-Output table without the need to reconstruct the Input-Output table from a newly disaggregated supply table. In the creation of the disaggregated input-output table, the aggregate figures from the original published Input-Output table for 2010 (Table 9) from the CSO are assumed to be correct with all balancing adjustments made with respect to preserving these values (CSO,2014).

With respect to product taxes and subsidies, in almost all instances, reliable information on product taxes and subsidies was not available for the disaggregated marine sectors. The nominal values for the "Product taxes less subsidies" row were calculated pro-rata on the basis of the ratio of total output from the sub-sector over the sector or sectors (in the case of Marine Tourism) from which they are disaggregated from. Similarly, where data was unavailable on the individual components of GVA, estimates are based on the ratio of total output from the sub-sector over the sector from which it was disaggregated from multiplied by the GVA reported in the Ocean Economy Report (Vega et al., 2015)

Where it is logically assumed that output from a sector that has a disaggregated marine component marine sector flows to another sector that has a disaggregated marine component, the table will reflect that inter-marine sectoral product flow. For example, for the fishing sector it is assumed that output flows from Repair and installation of machinery (NACE 33), Construction (NACE 42), Rental and Leasing (NACE 77) will come from the newly disaggregated marine sector element of those sectors.

In the 2010 Supply, Use and Input-Output tables, published by the CSO, total imported intermediate inputs by product are recorded in Table 10, which when subtracted from Total

Product Flows (Table 8) give the Symmetric Input-Output Table of Domestic Product Flows (Table 9); from which the Leontief Inverse matrix is calculated. Import ratios for each product's intermediate consumption across all sectors were calculated and applied to the estimated intermediate inputs with the balance aggregated and reported as required imports in the production process.

*Balancing*

While a number of different methods were investigated to aid in the balancing of Input-Output tables the decision was taken to balancing the disaggregated table manually. While a number of balancing methods such as Cross-Entropy and GRAS were investigated some unexpected results and in some case perverse outcomes were observed. All values across the newly disaggregated rows and columns require individual scrutiny and must be deemed credible in the context of the original input-output table and in the face of expert sectoral knowledge. Pragmatic balancing decisions have been made where significant imbalances were detected particularly in regards to the destination of product outputs where very little information is available. Any remaining nominal imbalances have been balanced though Final demand.

### 4.3 DISAGGREGATION OF MARINE SECTORS.

This section summarises the primary data sources and sector specific assumptions used in the disaggregation of eight Marine sectors and their subsectors from the relevant rows and columns in the Original Symmetric Input-Output table of Domestic Product Flows.

*Sea Fisheries*

The Sea Fisheries sector is disaggregated from the "Agriculture, forestry and fishing" sector (NACE 1-3). Figures for turnover, GVA, employment and exports for sea fisheries for 2010 are taken from the Irish Ocean Economy Report (Vega et al., 2015) on the basis of An Bord Iascaigh Mhara (BIM) data reported to the Scientific, Technical and Economic Committee for Fisheries (STECF) in their annual economic report on the EU Fishing Fleet. Estimates of the input profile of intermediate consumption for the sea fishing industry were initially developed on the basis of case studies and a multiplier study of the Scottish Fishing Industry (University of Strathclyde 2002). In consultation with BIM, estimates of the input profile of intermediate consumption for the Irish sea fishing industry were elicited from BIM's Annual Economic Survey. Where possible, inputs were mapped directly to their corresponding sectors in the Input-Output table e.g. the intermediate consumption of fuel and oil was assigned wholly and directly to Motor fuel and vehicle trade and repair (NACE 45). However, where direct assignation is not possible, such as in the case of miscellaneous input expenditure, pragmatic assumptions are required. One example of this is the pro-rata allocation of expenditure on "other services" across the all service sectors (NACE 53-97) in shared proportions. In relation to the destination of output from Sea Fisheries, approx. 20% was assumed to flow directly to the seafood processing sector while the remaining 80% of output was assumed to flow directly to export markets, following the export ratio reported in the 2010 Ocean Economy Report (Vega et. al, 2014)

*Aquaculture*

The Aquaculture sector is also disaggregated from the "Agriculture, forestry and fishing sector" (NACE 1-3). For the aquaculture sector, figures for turnover, GVA, and employment for 2010 were sourced from BIM data reported to the STECF in their annual report on the economic performance of the EU aquaculture sector providing a basis for the estimation of intermediate consumption. Due to the limited availability of detailed survey information on inputs in the Irish aquaculture industry, intermediate consumption shares for the aquaculture sector are apportioned on the basis of input shares calculated from fish farm case studies. Equivalent input shares reported in a prospective analysis of the aquaculture sector in the EU published by the Joint Research Centre (European Commission, 2008) were found to be comparable. With respect to output, it is assumed that the direct export profile for 2010 matches that reported in the Irish Ocean Economy Report (Vega et al., 2015) at 24.5% with 63.5% flowing directly as input into the seafood processing sector and the remaining 12% flowing as input back into Aquaculture for own use in the form of juveniles.

*Oil & Gas*

The Oil & Gas sector is disaggregated from the “Mining, quarrying and extraction” sector (NACE 5-9). Data for the Oil & Gas sector was observed from the CSO’s CIP using NACE sector identifiers 06.1, 8.12 & 09.9. While the CIP offers a wealth of valuable information enabling the precise calculation of intermediate consumption, sufficiently detailed information on input ratios is not available, necessitating a number of assumptions. Intermediate consumption identified as Materials and Fuels was allocated pro-rata to NACE sectors 1-25 & 35. Expenditure on Industrial Services was allocated to NACE sectors 26-33 and 36-46 while expenditure on Non-Industrial Services was allocated to NACE sectors 47-97. Total output from the Oil & Gas sector was allocated on the basic of Output shares created from the original mining, quarrying and extraction row in the Input-Output table. The resulting nominal values were then scaled to match the output totals from the Ocean Economy Report.

*Seafood Processing*

The Seafood Processing sector is disaggregated from the “Food & beverages and tobacco products” sector (NACE 10-12). Data on Seafood processing was observed from the CIP using the NACE sector identifier 10.2 Again, intermediate consumption identified as Materials and Fuels was allocated pro-rata to NACE sectors 1-25 & 35. Expenditure on Industrial Services was allocated pro-rata to NACE sectors 26-33 and 36-46 while expenditure on Non-Industrial Services was allocated to NACE sectors 47-97. Total output from Seafood Processing sector was allocated on the basic of Output shares created from the original food and beverages row in the Input-Output table.

*Marine Manufacturing and Construction*

The marine manufacturing and construction sector consists of four sub-sectors drawing on data from 3 different sources summarised in Table 3.1. The Marine Transport Equipment (NACE 30.1) sector and the Marine Repair/Installation (NACE 33.12) sector have been disaggregated from the "Other transport equipment" (NACE 30) and "Repair/installation of machinery & equipment" (NACE 33) sectors respectively using data from the CIP. The allocation of intermediate consumption and output follows the same method reported for the Seafood Processing and Oil and Gas sectors. Using information on turnover, intermediate consumption and GVA from the BCI, the Marine Construction (NACE 42.91) sector has been disaggregated pro-rata from the "Construction and construction works" (NACE 41-43) sector on the basis of the original sectoral input and output shares. Finally, the remaining balances for Output, GVA and employment reported for the marine manufacturing and construction in the Ocean Economy report were allocated to the Marine Engineering sub-sector and disaggregated from the “Architectural and engineering services” sector pro-rata on the basis of the original sectoral input and output shares (NACE 71).

*Marine Retail*

The Marine Retail sector is disaggregated from the “Retail Trade” sector (NACE 47) using information on the retail sale of fish, crustaceans and molluscs in specialised stores from the ASI (NACE 47.23) and information from the SEMRU company survey on companies conducting boat sales and chandlery services from which total output, and GVA is estimated. By subtracting GVA and a pro-rata output-based estimate of product taxes less subsidies from the estimated total output an estimate of intermediate consumption is made. Intermediate consumption, GVA and the row destination of output from the Marine Retail sector is the estimated pro-rata on the basis of the original s NACE 47 sectoral input and output shares from the Input-Output table.

*Shipping and Transport*

The Shipping and Transport sector consists of three sub-sectors drawing on data from the ASI. Firstly, Marine water transport services consist of Sea and coastal passenger transport (NACE 50.1) and sea and coastal freight water transport (NACE 50.2) and are disaggregated from the “Water Transport Services” sector (NACE 50) which includes inland water transport services which are not classified as marine. Secondly, marine warehousing consists of service activities incidental to water transportation (NACE 52.22), cargo handling (NACE 52.24) and other transportation support activities (52.29) which are disaggregated from the “Warehousing” sector (NACE 52). However, recorded activity for those sub-sectors can only be classified as partially marine therefore, a proxy, i.e. the percentage of trade by sea on the basis of the INTRASTAT trade statistics was used to estimate the support warehousing activities related to the marine sector. Thirdly, the rental and leasing of water transport equipment (NACE 77.34) is disaggregated from the “Rental and leasing services” sector (NACE 77). For all subsectors, the input column and output row is estimated pro-rata on the basis of the sectoral input and output shares from the original Input-Output table.

*Marine Tourism*

Estimates for the value of Marine Tourism come from two primary sources, the Marine Institute’s national survey of the share of expenditure on water-based leisure activities by domestic residents (ESRI, 2004) and a 2003 study by Fáilte Ireland on the expenditure of overseas visitors engaged in marine activities. Fáilte Ireland annually estimates the number and expenditure of overseas and domestic visitors. The overall expenditure by national and international visitors in the marine sector is updated to 2010 using Fáilte Ireland estimates from 2004 through to 2014 (Fáilte Ireland, 2015). Employment figures for domestic and overseas visitors are computed according to the average change in employment experienced by the overall Irish tourism sector. In terms of its disaggregation in the Bio-Economy Input Output model, the Marine Tourism sector is unique in that is it disaggregated from both the “Travel and tourism service activities” sector (NACE 79) and the “Accommodation and food & beverage services” sector (NACE 55-56). This is because the estimates for output for the Marine tourism sector include expenditure on accommodation, food and beverages in the pursuit of marine tourism. The input column and output row for Marine Tourism is estimated on the basis of the sectoral input and output shares from the from the combined row and column totals of the “Travel and tourism service activities” sector (NACE 79) and the

"Accommodation and food & beverage services" sector (NACE 55-56) in the original Input-Output table.

## 4.4 Summary and Conclusions

The 2010 Symmetric Input-Output Table has been disaggregated to include an additional eight marine based sectors consistent with the estimates for output, GVA and exports in the most recent Ocean Economy Report (Vega et. al 2015). This facilitated the construction of the Bio-Economy Input Output model from which the Leontief Inverse matrix and subsequent multiplier analyses can be performed. This provides a structured approach to analysing the position of the marine sector with respect to the rest of the economy. It summarises the source of inputs and the destination of outputs for all sub sectors and provides a means of studying the intensity and direction of relationships between the marine and other production sectors. The disaggregation of the marine sectors in the Bio-Economy model is a constantly evolving process which can be improved upon over time. This may occur due to the identification of new areas of the economy which may be classified as fully or partially marine in the future. Improvement could also be made with the availability of new data sources, the restructuring of existing data sources or simply the refinement of existing assumptions.

The decision to add additional sectors in the model in the future however, should not be made lightly. As outlined in the previous section, a considerable number of assumptions and pragmatic decisions have been required to be made in the construction of the model. Each additional sector requires the calculation of $2(n+1)$[8] new entries in the table increasing the models complexity as well as adding to the list of assumptions required to credibly populate the entries and maintain a balanced symmetric table. In addition, the greater the level of disaggregation the less confident we can be about assumptions which rely on the existing sectoral input and output ratios gleaned from the original 2010 Input-Output table.

The marine employment multipliers are currently based on average employment coefficients which assume the maintenance of 2010 labour/output ratios. This has the potential to dominate the estimated total employment effect in possible future scenario analysis. In reality economies of scale and improvements in productivity with the adoption of improved production methods are likely to be achieved resulting in an overestimation of future employment impacts. The estimation of marginal employment multipliers is a preferable approach however there is a significant shortfall in the availability of suitable data. While the agricultural sector can draw on the Teagasc National Farm Survey which contains over 40 years of data on the relationship of employment to output, only 5 years of data over an 8 year period is available from the Ocean Economy Series (Vega et al, 2015) In addition, those data years coincide with the recent recession making the elicitation of reliable marginal employment coefficients extremely difficult. Consistency of measurement, additional detail on the determinants of output at the unit level and additional years of observation will be required in order to facilitate the estimation of more reliable marginal multipliers in the future.

Finally, while an 8 sector marine disaggregation is ultimately reported in order to maintain a reporting structure consistent with the Ocean Economy series, the dominance of the Shipping and Transport sector over all other sectors in terms of nominal values would merit the

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[8] (where n = the number of original sectors)

consideration of reporting the individual Shipping and Transport sub-sectors listed in Table 4.1

# Chapter 5. EMPLOYMENT MULTIPLIERS OF THE FOOD WISE 2025 STRATEGY

Eoin Grealis, Cathal O'Donoghue, Thia Hennessy and Trevor Donnellan

## 5.1 INTRODUCTION

In this chapter, we describe the calculation of an estimate of the potential jobs generated from reaching growth scenarios suggested by the Food Wise 2025 (FW2025) committee for a variety of different sectors.

The analysis utilises the Bio-Economy Input-Output model developed by NUI Galway and Teagasc (O'Donoghue et al., forthcoming) and building upon previous work led by Prof Alan Matthews (Miller et al., 2014). The Socio-Economic Marine Research Unit of NUI Galway and the Rural Economy and Development Programme of Teagasc have developed, under Beaufort Award funding in association with the Marine Institute, an economic impact assessment model, namely, the Bio-Economy Input-Output Model. This model has been developed to assess the output and employment multipliers of public policy initiatives such as the Food Wise 2025 strategy and Harvesting Our Ocean Wealth strategy.

The model disaggregates the national Input-Output Model of the CSO to incorporate primary, industry and service sectors across the Bio-Economy incorporating detailed Agri-Food, forestry and marine sectors. Given the combination of a wide variety of data sources, the generation of an input-output model comes at quite a significant time lag. The most recent version is for 2010. It thus incorporates the impact of the crisis but does not capture changes since the start of the economic recovery in early 2012.

This model captures economic flows between these and other sectors in the economy, inputs such as labour, profit and imports and final destinations such as households, industry, government and exports. It builds upon earlier work done in collaboration with Prof. Alan Matthews, formerly of Trinity College Dublin and by Dr Aine Ni Dhubhain and Dr Richard Moloney for the forestry sector. The formal launch of the new model is planned on September 9th in Dublin.

In addition to being utilised for Food Wise 2025 job creation targets, at the Harvesting our Ocean Wealth Conference event on July 10th and 11th, it is hoped to launch results in relation to the employment multipliers associated with Harvesting Our Ocean Wealth.

The challenge whenever developing an input-output model is that the data used to develop the model are taken from different sources, collected from different sources and not necessarily consistent. Nevertheless the rows of outputs and columns of inputs in the final model must tally. An extensive set of assumptions are utilised to ensure that the model balances. Frequently in developing these models, a "black box" based auto-computational method is used to ensure balancing. However, this can result in implausible flows within the model as these matrix balancing mechanisms are not bound by economic theory. The model developers have therefore opted to use expert judgement in order to balance the model. This decision significantly lengthened the development process; however it was deemed a necessary action in order to deliver a more plausible model.

It should be noted that this is the first implementation of the new Bio-Economy model, which involves extensive analysis of the flows between sub-sectors in the Teagasc National Farm Survey to establish flows at farm level between sub-sectors, the disaggregation of processing sector, forestry and marine sectors. Primary validation has taken place, both in terms of the initial model components and their consistency with national accounts and in comparison with the earlier results from Miller et al. (2011a). In addition a comprehensive validation process has taken place to ensure reliability and consistency of the overall model.

In this chapter we focus initially on the main animal and meat based scenarios as most of the employment targets are driven by these sectors. Subsequently a more detailed focus on issues like forestry (with forestry economics experts, Aine Ni Dhubhain, Richard Moloney and Mary Ryan), cereals and land will be undertaken.

## 5.2 FW2025 Growth Scenarios

In this section, we report one possible set of growth scenarios suggested by the FW2025 committee by sub-sector in different dimensions including animal numbers, land and output targets. In this study, we do not comment on the feasibility, development pathway, consistency, policy/market levers required, or otherwise of meeting the goals set by the FW2025 committee. Rather, the focus is on trying to understand the employment creation potential of achieving the simulated growth levels. .

Table 5.1 details the specific projection assumptions at sectoral level under base case and base case+ scenarios to 2025 relative to the 2012-2014 average. These are both 5 years later in terms of both target and baseline relative to the Food Harvest 2020 targets.

**Table 5.1 Projection Assumptions for 2025 relative to 2012-2014 Average in Base Case and Base Case+**

| | Realistic Change by 2025 (%) compared to current baseline | |
|---|---|---|
| *Category* | Base Case | Base Case + |
| Total Cattle (000s) | 8.0% | 10.0% |
| Dairy Cows (000s) | 20.0% | 30.0% |
| Other Cows (000s) | -10.0% | 0.0% |
| Total Sheep (000s) | 10.0% | 15.0% |
| Ewes (000s) | 0.0% | 10.0% |
| Total Pigs (000s) | 10.0% | 17.0% |
| Breeding Pigs (000s) | 0.0% | 10.0% |
| Poultry (000s) | 45.0% | 100.0% |
| *Production Volume* | 0.0% | 0.0% |
| Milk (Million Litres) | 49.3% | 64.2% |
| Barley (000 tonnes) | 19.4% | 34.2% |
| Wheat (000 tonnes) | 3.4% | 6.7% |
| Oats (000 tonnes) | 10.2% | 31.1% |
| Peas & Beans (000 tonnes) | 51.0% | 253.0% |
| Oilseed Rape (000 tonnes) | 1.0% | 175.0% |
| Maize Silage (ha) | 53.0% | 91.0% |
| Seafood (000 tonnes) | 13.7% | 62.4% |
| Forestry Planting | 53.4% | 130.1% |

In modelling the employment impact of reaching these growth levels, we consider the impact across the wider value chain. As a result we focus on the change in processed sector outputs, with upstream primary sector impacts in terms of animals and input feed etc. being driven by these changes. So for example milk production utilised at processing scale drives the animal number targets and much of the cereals produced. Given differences between the assumptions within the BIO model and in the assumptions used by the FW2025, there may be differences in some of the upstream targets. We do not at present consider land use targets in this analysis. A variant of the model is currently being developed to consider land use inputs.

While milk volume, pig and poultry scenarios are reasonably clear in terms of processing sector volume changes, given the linkage between primary and processing sector, the beef meat volume growth scenario is less clear, depending as it does on both the output from the dairy farm sector and the cattle farm sector. In Table 5.2, we convert the dairy and cattle sector animal assumptions into a beef meat volume assumption. The table incorporates the distribution of animal numbers and the replacement animals required for the dairy herd and live export assumptions. It assumes that domestic Beef Cattle going to processing would grow by 6.2% in the base case scenario and 7% in the base+ scenario. Further consultation will take place in relation to the appropriateness of these assumptions.

**Table 5.2 Growth in Beef Output as a result of changes in Dairy and Cattle Sector (€m)**

| | Avg 12-14 | Base Case | Base Case + | Base Case% | Base Case% + |
|---|---|---|---|---|---|
| Total cattle | 6268 | 6770 | 6895 | 8.0% | 10.0% |
| Cows | 2175 | 2284 | 2502 | 5.0% | 15.0% |
| Dairy cows | 1090 | 1308 | 1417 | 20.0% | 30.0% |
| Other cows | 1085 | 976 | 1085 | -10.0% | 0.0% |
| Bulls | 37 | 40 | 41 | 8.0% | 10.0% |
| Cattle: 2 years and over | 474 | 512 | 522 | 8.0% | 10.0% |
| Cattle male: 2 years and over | 189 | 204 | 208 | 8.0% | 10.0% |
| Cattle female: 2 years and over | 285 | 308 | 314 | 8.0% | 10.0% |
| Cattle: 1-2 years | 1660 | 1793 | 1826 | 8.0% | 10.0% |
| Cattle male: 1-2 years | 766 | 827 | 842 | 8.0% | 10.0% |
| Cattle female: 1-2 years | 894 | 966 | 984 | 8.0% | 10.0% |
| Cattle: under 1 year | 1922 | 2076 | 2114 | 8.0% | 10.0% |
| Cattle male: under 1 year | 934 | 1009 | 1028 | 8.0% | 10.0% |
| Cattle female: under 1 year | 988 | 1067 | 1086 | 8.0% | 10.0% |
| Total cattle: male | 1926 | 2080 | 2119 | 8.0% | 10.0% |
| Total cattle: female | 4342 | 4690 | 4776 | 8.0% | 10.0% |
| Live Exports | 314 | 339 | 346 | 8.0% | 10.0% |
| Replacement Dairy Animals under 2 | 436 | 523 | 567 | 20.0% | 30.0% |
| Cattle 1-2 that will progress to 2+ | 474 | 512 | 522 | 8.0% | 10.0% |
| Replacement Dairy Animals aged 1 | 218 | 262 | 283 | 20.0% | 30.0% |
| Domestic Beef Cattle going to processing | 1442 | 1531 | 1542 | 6.2% | 7.0% |
| Cattle due to live exports | | | | 1.4% | 1.8% |

The CSO CIP disaggregates food production into a meat industry sub-sectors and other sub-sectors. Miller et al. (2014) further disaggregated the meat sector into beef, sheep, pig and poultry based sectors. However as this involves extra assumptions over and above those contained in the CSO data, we prefer to reduce risk by maintaining the more aggregated meat sector. As a result it is necessary to combine the meat sub-sectors into a total meat sector.

Table 5.3 draws upon meat supply totals from the CSO for 2010 to weight individual meat growth scenarios into an aggregate target of 12% volume growth in the base case scenario and 22% in the base+ scenario.

**Table 5.3 Increase in Meat Volume as a result of Individual Scenarios '000 Tonnes**

| Meat Slaughtering | 2010 | Base | Base+ |
|---|---|---|---|
| Beef and veal | 558 | 1.06 | 1.07 |
| Pig meat | 215 | 1.10 | 1.17 |
| Sheep meat | 48 | 1.10 | 1.15 |
| Poultry meat | 126 | 1.45 | 2.00 |
| Other meat | 11 | 1.00 | 1.00 |
| | | | |
| Total | 958 | 1.12 | 1.22 |

Table 5.4 thus represents the volume growth assumptions for the main meat and animal based scenarios. In order to separately identify the differential employment creation totals, we split the base case scenarios into sub-scenarios for base and base+ cases:

- Meat and Meat Products
- Seafood Processing
- Dairy Products

The Seafood and Dairy scenarios depend directly upon volume scenarios suggested by the FW2025 committee, while the meat scenario draws upon the analysis undertaken by these authors in Tables 5.3 and 5.2

**Table 5.4 Individual Processing Sectoral Growth Assumptions**

| Sectoral Scenario | Meat | Seafood | Dairy | Meat | Seafood | Dairy |
|---|---|---|---|---|---|---|
| Scenario Type | Base | Base | Base | Base+ | Base+ | Base+ |
| Scenario No. | 1 | 2 | 3 | 4 | 5 | 6 |
| Meat and Meat Products | 1.12 | 0 | 0 | 1.22 | 0 | 0 |
| Seafood Processing | 0 | 1.14 | 0 | 0 | 1.22 | 0 |
| Dairy Products | 0 | 0 | 1.49 | 0 | 0 | 1.64 |

## 5.3 Calculation of Multipliers

The employment impact of a volume change in output depends upon 3 factors

- The size of the output shock or change
- The interaction between different sectors as defined by the Leontief Inverse Matrix within the Input-Output table
- The employment to output ratio

In Table 5.4, we described the size of the increase in output. In this section we describe and provide initial validation for the output multipliers.

Table 5.5 provides the output multipliers from the original un-disaggregated CSO 2010 Input-Output model. The Agriculture, forestry and fishing sector has an output multiplier of 1.97, while the Food & beverages and tobacco products sector has an output multiplier of 1.98.

**Table 5.5 Total Output Multipliers from the 2010 CSO Input-Output Table**[9]

| Sector | Output Multiplier |
|---|---|
| Agriculture, forestry and fishing | 1.97 |
| Mining, quarrying and extraction | 1.14 |
| Food & beverages and tobacco products | 1.98 |
| Textiles, wearing apparel and leather products | 1.09 |
| Wood and wood products (excl furniture) | 2.01 |
| Pulp, paper and paper products | 1.33 |
| Printed matter and recorded media | 1.74 |
| Petroleum; furniture; other manufacturing | 1.45 |
| Chemicals and chemical products | 1.26 |
| Basic pharmaceutical products | 1.94 |
| Rubber and plastics | 1.37 |
| Other non-metallic mineral products | 1.82 |
| Basic metals | 1.37 |
| Fabricated metal products | 1.48 |
| Computer, electronic & optical products | 1.69 |
| Electrical equipment | 1.38 |
| Machinery and equipment n.e.c. | 1.43 |
| Motor vehicles, trailers and semi-trailers | 1.22 |
| Other transport equipment | 1.07 |
| Repair/installation of machinery & equipment | 1.91 |
| Electricity and gas supply | 1.67 |
| Water collection, treatment and supply | 1.86 |
| Sewerage, refuse and remediation services | 1.69 |
| Construction and construction works | 2.31 |
| Motor fuel and vehicle trade and repair | 1.66 |
| Wholesale trade | 1.58 |
| Retail trade | 1.71 |
| Land transport services | 1.98 |
| Water transport services | 1.90 |
| Air transport services | 1.52 |
| Warehousing | 1.91 |
| Postal and courier services | 1.63 |
| Accommodation and food & beverage services | 1.63 |
| Publishing, film and broadcasting services | 1.93 |
| Telecommunications services | 1.69 |
| Computer consultancy; data processing | 2.11 |
| Financial intermediation services | 1.62 |
| Insurance, reinsurance and pension funding | 1.80 |
| Other financial activities | 1.75 |
| Real estate services | 1.68 |
| Legal and accounting services; mgt consultancy | 1.86 |
| Architectural and engineering services | 1.54 |
| Scientific research and development services | 1.25 |
| Advertising and market research services | 1.05 |
| Other professional, scientific services | 1.40 |
| Rental and leasing services | 1.19 |
| Employment services | 1.22 |

[9] The output multipliers displayed in Table 5.5 are based on the Leontief Inverse Matrix of total product flows calculated from Table 8 of the 2010 Supply, Use, Input-Output tables. These multipliers form the basis of the subsequent comparison with the employment analysis of Miller et al. (2014) and the investigation of the investment impact of dairy expansion in Chapter 7. A comparison of the employment impacts using both the total and domestic output multipliers (displayed in Table 7.4) found no discernible difference. The final published Bio-Economy Input-Output Table and accompanying Leontief Inverse Matrix published takes account of the imported share of intermediate consumption of inputs and forms the basis of the analysis performed in Chapter 6 & Chapter 8.

| | |
|---|---|
| Travel and tourism service activities | 2.24 |
| Security, office & business support services | 1.30 |
| Public administration | 1.66 |
| Education services | 1.36 |
| Human health and social work services | 1.35 |
| Cultural and sporting services | 1.41 |
| Recreation services | 1.28 |
| Membership organisation services | 2.16 |
| Repair of consumer goods | 2.55 |
| Other services | 2.42 |
| Private households with employed persons | 1.00 |

In Table 5.6 we report the disaggregated output multipliers for detailed farm level sub-sectors and in Table 5.7, the disaggregated output multipliers for detailed food processing sectors. The process of generating these multipliers is described in O'Donoghue et al., (forthcoming). While there is a reasonably broad spread of multipliers within the two sectors, (from Horticulture to Pigs and Poultry on the primary side and from Other Food Products to Meat on the processing side, what one can say at this early stage of validation is that the range is not implausibly large and as a result is unlikely to have a qualitative difference on overall results.

**Table 5.6 Disaggregated Total Output Multipliers for Agriculture, Forestry and Fishing**

| Sector | Output Multiplier |
|---|---|
| Agriculture, forestry and fishing | 1.97 |
| Forestry | 2.20 |
| Commercial Fishing | 1.77 |
| Aquaculture | 2.27 |
| Concentrate Feed | 1.59 |
| Pasture | 1.95 |
| Winter Forage | 1.86 |
| Silage | 1.68 |
| Hay | 1.85 |
| Other Cash Crop | 1.48 |
| Potato Fruit Vegetable | 1.14 |
| Setaside | 1.83 |
| Sugar Beet | 2.45 |
| Dairy | 1.93 |
| Cattle | 2.51 |
| Sheep | 2.20 |
| Horses | 2.14 |
| Pigs | 2.72 |
| Poultry | 2.86 |
| Deer and Goats | 1.77 |

**Table 5.7 Disaggregated Total Output Multipliers for Food & beverages and tobacco products**

| Sector | Output Multiplier |
|---|---|
| Food & beverages and tobacco products | 1.98 |
| Meat and Meat Products | 2.40 |
| Seafood Processing | 2.12 |
| Fruit and Vegetables | 1.99 |
| Vegetable, Animal oils and fats | 2.17 |
| Dairy Products | 2.21 |

| | |
|---|---|
| Grain mill products, starches and starch products | 1.62 |
| Bakery and Farinaceous Products | 2.00 |
| Other Food Products | 1.75 |
| Prepared Animal Feeds | 2.00 |
| Beverages | 1.97 |

### 5.4 CALCULATING EMPLOYMENT MULTIPLIERS

In Table 5.8, we report the calculation of employment multipliers. These depend upon the output per sector, the employment per sector and the Leontief Inverse Matrix that describes the total flows between sectors coming from the BIO model.

**Table 5.8 Employment Multipliers based upon Average Elasticities**

| | Output (€m) | Output Multipliers | Employment (000's) | FTE/€m | Employment Multipliers | Total Employment Effects/€m | Direct Employment Effect | Indirect Employment Effect |
|---|---|---|---|---|---|---|---|---|
| Forestry | 415 | 2.20 | 6 | 15 | 1.22 | 18.3 | 15.1 | 3.3 |
| Commercial Fishing | 201 | 1.77 | 3 | 14 | 1.50 | 21.0 | 14.0 | 7.0 |
| Aquaculture | 125 | 2.27 | 1 | 7 | 1.80 | 13.2 | 7.4 | 5.9 |
| Concentrate Own | 373 | 1.59 | 4 | 10 | 1.14 | 11.3 | 9.9 | 1.4 |
| Concentrate Opening | 27 | 1.48 | 0 | 10 | 1.22 | 12.0 | 9.9 | 2.1 |
| Pasture | 248 | 1.95 | 4 | 17 | 1.12 | 18.6 | 16.6 | 2.0 |
| Winter Forage Own | 50 | 1.86 | 1 | 17 | 1.12 | 18.5 | 16.6 | 2.0 |
| Silage own | 382 | 1.68 | 6 | 17 | 1.12 | 18.6 | 16.6 | 2.0 |
| Hay Own | 31 | 1.85 | 1 | 17 | 1.15 | 19.0 | 16.6 | 2.4 |
| Winter Forage Op | 43 | 2.29 | 1 | 17 | 1.05 | 17.5 | 16.6 | 0.9 |
| Silage Op | 0 | 1.55 | 0 | 17 | 1.13 | 18.7 | 16.6 | 2.2 |
| Hay Op | 0 | 1.00 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| Winter Forage Pur | 0 | 1.00 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| OtherCashCrop | 107 | 1.48 | 1 | 10 | 1.11 | 10.9 | 9.9 | 1.1 |
| PotatoFruitVeg | 1327 | 1.14 | 13 | 10 | 1.05 | 10.3 | 9.9 | 0.4 |
| Setaside | 0 | 1.83 | 0 | 10 | 1.26 | 12.5 | 9.9 | 2.6 |
| SugarBeet | 0 | 2.45 | 0 | 10 | 1.47 | 14.5 | 9.9 | 4.7 |
| Dairy | 1581 | 1.93 | 16 | 10 | 1.50 | 14.9 | 9.9 | 5.0 |
| Roots | 0 | 1.00 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| Milk Quota Lease | 0 | 1.00 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| HOME_GROWN_SEED_VALUE_EU | 0 | 1.00 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| MACHINERY_HIRE_EU | 293 | 1.01 | 3 | 10 | 1.00 | 9.9 | 9.9 | 0.0 |
| Cattle | 1692 | 2.51 | 31 | 19 | 1.49 | 27.6 | 18.6 | 9.0 |
| Sheep | 168 | 2.20 | 3 | 19 | 1.30 | 24.2 | 18.6 | 5.6 |
| Horses | 153 | 2.14 | 3 | 17 | 1.29 | 21.5 | 16.6 | 4.9 |
| Pigs | 339 | 2.72 | 6 | 17 | 1.36 | 22.6 | 16.6 | 6.0 |
| Poultry | 137 | 2.86 | 2 | 17 | 1.42 | 23.5 | 16.6 | 6.9 |
| Deer and Goats | 42 | 1.77 | 1 | 17 | 1.23 | 20.4 | 16.6 | 3.8 |
| Mining, quarrying and extraction | 3781 | 1.12 | 6 | 2 | 1.26 | 2.1 | 1.7 | 0.4 |
| Meat and Meat Products | 5371 | 2.40 | 12 | 2 | 6.06 | 13.8 | 2.3 | 11.5 |
| Seafood Processing | 391 | 2.12 | 2 | 4 | 2.56 | 10.6 | 4.1 | 6.4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fruit and Vegetables | 217 | 1.99 | 1 | 7 | 1.69 | 11.0 | 6.5 | 4.5 |
| Vegetable, Animal oils and fats | 28 | 2.17 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| Dairy Products | 4758 | 2.21 | 5 | 1 | 6.91 | 7.2 | 1.0 | 6.2 |
| Grain mill products, starches and starch products | 60 | 1.62 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.0 |
| Bakery and Farinaceous Products | 620 | 2.00 | 5 | 9 | 1.64 | 14.3 | 8.8 | 5.6 |
| Other Food Products | 10318 | 1.75 | 6 | 1 | 4.56 | 2.8 | 0.6 | 2.1 |
| Prepared Animal Feeds | 1355 | 2.00 | 2 | 2 | 3.51 | 6.0 | 1.7 | 4.3 |
| Beverages | 2504 | 1.97 | 4 | 1 | 2.55 | 3.7 | 1.4 | 2.2 |
| Textiles, wearing apparel and leather products | 3240 | 1.09 | 5 | 2 | 1.14 | 1.9 | 1.7 | 0.2 |
| Wood and wood products (excl furniture) | 1036 | 2.06 | 5 | 5 | 2.18 | 10.9 | 5.0 | 5.9 |
| Pulp, paper and paper products | 1490 | 1.33 | 2 | 2 | 1.59 | 2.7 | 1.7 | 1.0 |
| Printed matter and recorded media | 1883 | 1.74 | 15 | 8 | 1.21 | 9.5 | 7.9 | 1.6 |
| Petroleum; furniture; other manufacturing | 14170 | 1.45 | 11 | 1 | 2.72 | 2.0 | 0.7 | 1.3 |
| Chemicals and chemical products | 18700 | 1.26 | 6 | 0 | 2.26 | 0.7 | 0.3 | 0.4 |
| Basic pharmaceutical products | 31392 | 1.94 | 29 | 1 | 2.60 | 2.4 | 0.9 | 1.5 |
| Rubber and plastics | 2529 | 1.37 | 6 | 2 | 1.56 | 3.5 | 2.3 | 1.3 |
| Other non-metallic mineral products | 2022 | 1.82 | 8 | 4 | 1.74 | 6.6 | 3.8 | 2.8 |
| Basic metals | 1669 | 1.37 | 2 | 1 | 1.71 | 2.5 | 1.4 | 1.0 |
| Fabricated metal products | 2215 | 1.48 | 13 | 6 | 1.24 | 7.5 | 6.1 | 1.5 |
| Computer, electronic & optical products | 16706 | 1.69 | 49 | 3 | 1.64 | 4.8 | 2.9 | 1.9 |
| Electrical equipment | 2519 | 1.38 | 4 | 2 | 1.79 | 2.9 | 1.6 | 1.3 |
| Machinery and equipment n.e.c. | 3580 | 1.43 | 10 | 3 | 1.53 | 4.2 | 2.7 | 1.5 |
| Motor vehicles, trailers and semi-trailers | 2228 | 1.22 | 3 | 1 | 1.63 | 1.9 | 1.2 | 0.7 |
| Other transport equipment | 3797 | 1.07 | 4 | 1 | 1.25 | 1.2 | 1.0 | 0.2 |
| Repair/installation of machinery & equipment | 619 | 1.92 | 19 | 30 | 1.14 | 34.5 | 30.4 | 4.2 |
| Electricity and gas supply | 5222 | 1.68 | 13 | 2 | 1.75 | 4.2 | 2.4 | 1.8 |
| Water collection, treatment and supply | 394 | 1.87 | 2 | 5 | 1.64 | 8.1 | 5.0 | 3.2 |
| Sewerage, refuse and remediation services | 1452 | 1.69 | 5 | 3 | 1.72 | 5.6 | 3.3 | 2.4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Construction and construction works | 13045 | 2.32 | 100 | 8 | 1.79 | 13.7 | 7.6 | 6.0 |
| Motor fuel and vehicle trade and repair | 1961 | 1.67 | 42 | 21 | 1.12 | 23.8 | 21.2 | 2.6 |
| Wholesale trade | 29904 | 1.58 | 82 | 3 | 1.70 | 4.7 | 2.7 | 1.9 |
| Retail trade | 11482 | 1.71 | 172 | 15 | 1.17 | 17.5 | 15.0 | 2.5 |
| Land transport services | 4501 | 2.02 | 45 | 10 | 1.49 | 15.1 | 10.1 | 5.0 |
| Water transport services | 3 | 3.93 | 0 | 3 | 6.04 | 20.0 | 3.3 | 16.7 |
| Air transport services | 6026 | 1.53 | 7 | 1 | 2.34 | 2.8 | 1.2 | 1.6 |
| Warehousing | 1640 | 1.73 | 6 | 4 | 1.90 | 6.9 | 3.6 | 3.3 |
| Postal and courier services | 2045 | 1.64 | 17 | 8 | 1.38 | 11.2 | 8.1 | 3.1 |
| Accommodation and food & beverage services | 10612 | 1.67 | 114 | 11 | 1.29 | 13.8 | 10.8 | 3.1 |
| Publishing, film and broadcasting | 13293 | 1.93 | 16 | 1 | 2.84 | 3.5 | 1.2 | 2.3 |
| Telecommunications services | 6487 | 1.69 | 16 | 3 | 2.04 | 5.1 | 2.5 | 2.6 |
| Computer consultancy; data processing | 22895 | 2.11 | 46 | 2 | 2.29 | 4.6 | 2.0 | 2.6 |
| Financial intermediation services | 22770 | 1.62 | 63 | 3 | 1.86 | 5.1 | 2.8 | 2.4 |
| Insurance, reinsurance and pension funding | 18451 | 1.80 | 22 | 1 | 2.48 | 2.9 | 1.2 | 1.7 |
| Other financial activities | 5307 | 1.76 | 18 | 3 | 1.86 | 6.4 | 3.4 | 2.9 |
| Real estate services | 15109 | 1.68 | 12 | 1 | 4.33 | 3.4 | 0.8 | 2.6 |
| Legal and accounting services; mgt consultancy | 7368 | 1.87 | 45 | 6 | 1.60 | 9.7 | 6.1 | 3.7 |
| Architectural and engineering services | 2730 | 1.52 | 19 | 7 | 1.48 | 10.1 | 6.8 | 3.3 |
| Scientific research and development services | 5944 | 1.26 | 5 | 1 | 2.85 | 2.2 | 0.8 | 1.4 |
| Advertising and market research services | 7623 | 1.05 | 6 | 1 | 1.29 | 1.1 | 0.8 | 0.2 |
| Other professional, scientific services | 8468 | 1.40 | 2 | 0 | 7.27 | 2.0 | 0.3 | 1.7 |
| Rental and leasing services | 39945 | 1.19 | 7 | 0 | 8.37 | 1.4 | 0.2 | 1.3 |
| Employment services | 1191 | 1.22 | 7 | 6 | 1.17 | 6.8 | 5.9 | 1.0 |
| Travel and tourism service activities | 1342 | 2.23 | 7 | 5 | 2.25 | 10.9 | 4.9 | 6.0 |
| Security, office & business support services | 2792 | 1.30 | 30 | 11 | 1.15 | 12.2 | 10.6 | 1.5 |
| Public administration | 12139 | 1.67 | 125 | 10 | 1.31 | 13.5 | 10.3 | 3.2 |
| Education services | 10655 | 1.36 | 181 | 17 | 1.13 | 19.2 | 17.0 | 2.3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Human health and social work services | 15448 | 1.35 | 224 | 15 | 1.16 | 16.8 | 14.5 | 2.3 |
| Cultural and sporting services | 2736 | 1.42 | 22 | 8 | 1.31 | 10.5 | 8.0 | 2.5 |
| Recreation services | 1208 | 1.28 | 7 | 6 | 1.21 | 7.1 | 5.8 | 1.3 |
| Membership organisation services | 1374 | 2.18 | 12 | 9 | 1.65 | 14.8 | 9.0 | 5.8 |
| Repair of consumer goods | 168 | 2.56 | 5 | 30 | 1.26 | 38.3 | 30.4 | 7.9 |
| Other services | 1131 | 2.43 | 29 | 25 | 1.27 | 32.0 | 25.2 | 6.7 |
| Marine-Mining, quarrying and extraction (Oil &Gas) | 126 | 1.87 | 2 | 18 | 1.19 | 22.0 | 18.4 | 3.6 |
| Marine other Transport Equipment | 8 | 2.06 | 0 | 1 | 5.63 | 5.5 | 1.0 | 4.5 |
| Marine Repair/Installation of Machinery | 17 | 1.83 | 1 | 30 | 1.07 | 32.5 | 30.4 | 2.2 |
| Marine Construction | 4 | 1.97 | 0 | 8 | 1.43 | 10.9 | 7.6 | 3.3 |
| Marine Retail Trade | 58 | 1.65 | 1 | 15 | 1.15 | 17.2 | 15.0 | 2.2 |
| Marine Water Transport Services | 567 | 2.04 | 2 | 3 | 2.41 | 8.0 | 3.3 | 4.6 |
| Marine Warehousing | 989 | 2.32 | 4 | 4 | 2.55 | 9.3 | 3.6 | 5.6 |
| Marine Engineering | 82 | 2.00 | 1 | 7 | 1.92 | 13.2 | 6.8 | 6.3 |
| Marine Rental and Leasing | 41 | 2.98 | 0 | 0 | | 15.7 | 0.2 | 15.5 |
| Marine Tourism | 841 | 2.10 | 4 | 5 | 1.94 | 9.4 | 4.9 | 4.6 |
| Private households with employed persons | 136 | 1.00 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.0 |

In Figure 5.1, we report the validation of the average employment multipliers, comparing those from the CSO original model with the BIO-based disaggregated totals. While sectors that have not been disaggregated have more or less the same multiplier, reassuring us about the internal consistency in the model, there is a wider range of estimates for the disaggregated sectors.

In general, we find that the range of estimates fall within the existing range of estimates. However the animal based sectors have higher employment multipliers than other sectors. This reflects the high under-employment reported in Figure 5.2.

These multipliers are average multipliers, assuming that employment would increase pro-rata with changes in output. This is an assumption often made in the use of Input-Output models in impact assessment analysis. However, given the under-employment exhibited in the agricultural sector, it is extremely unlikely that these employment growth rates would be generated as a result of the output shock identified above. As a result we develop two separate methodologies below to develop employment impacts

- A detailed farm-level simulation using Teagasc National Farm Survey Data
- An econometric analysis of marginal industrial employment elasticities

These are reported in the next sections

**Figure 5.1 Validation of Average Employment Multipliers due to disaggregation**

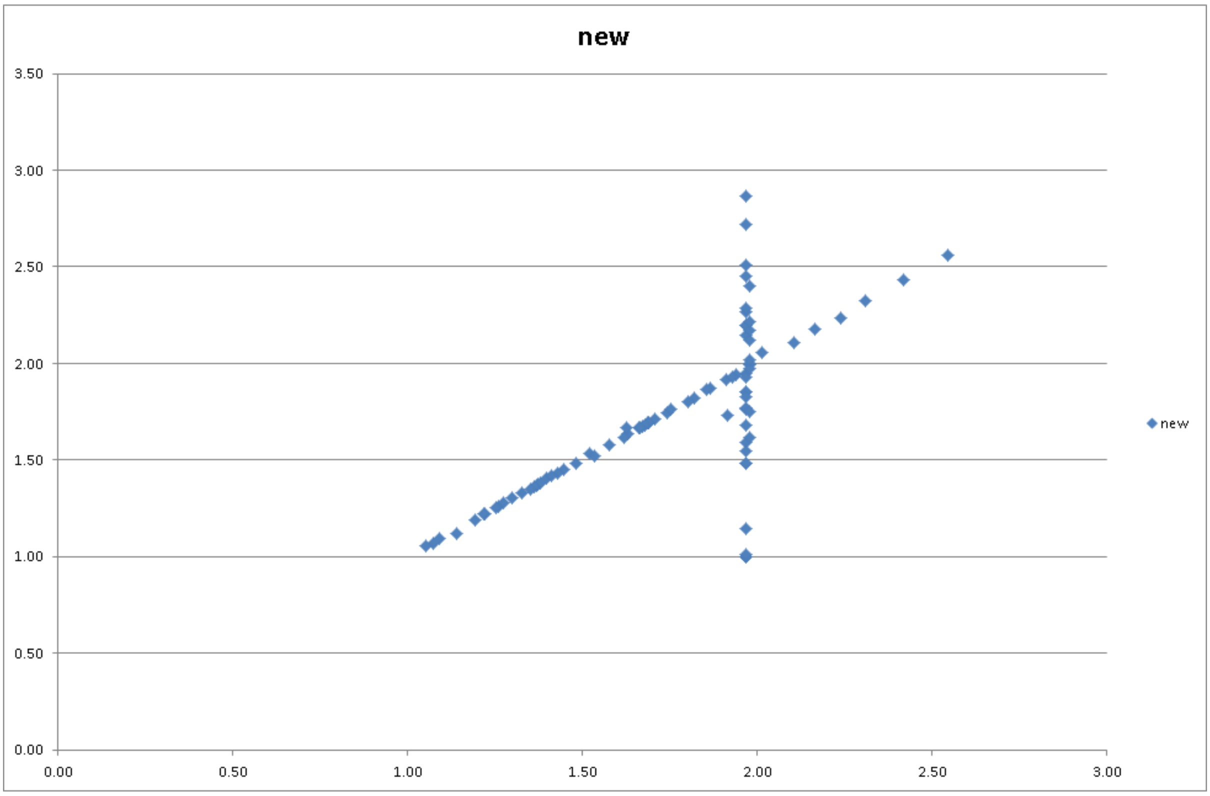
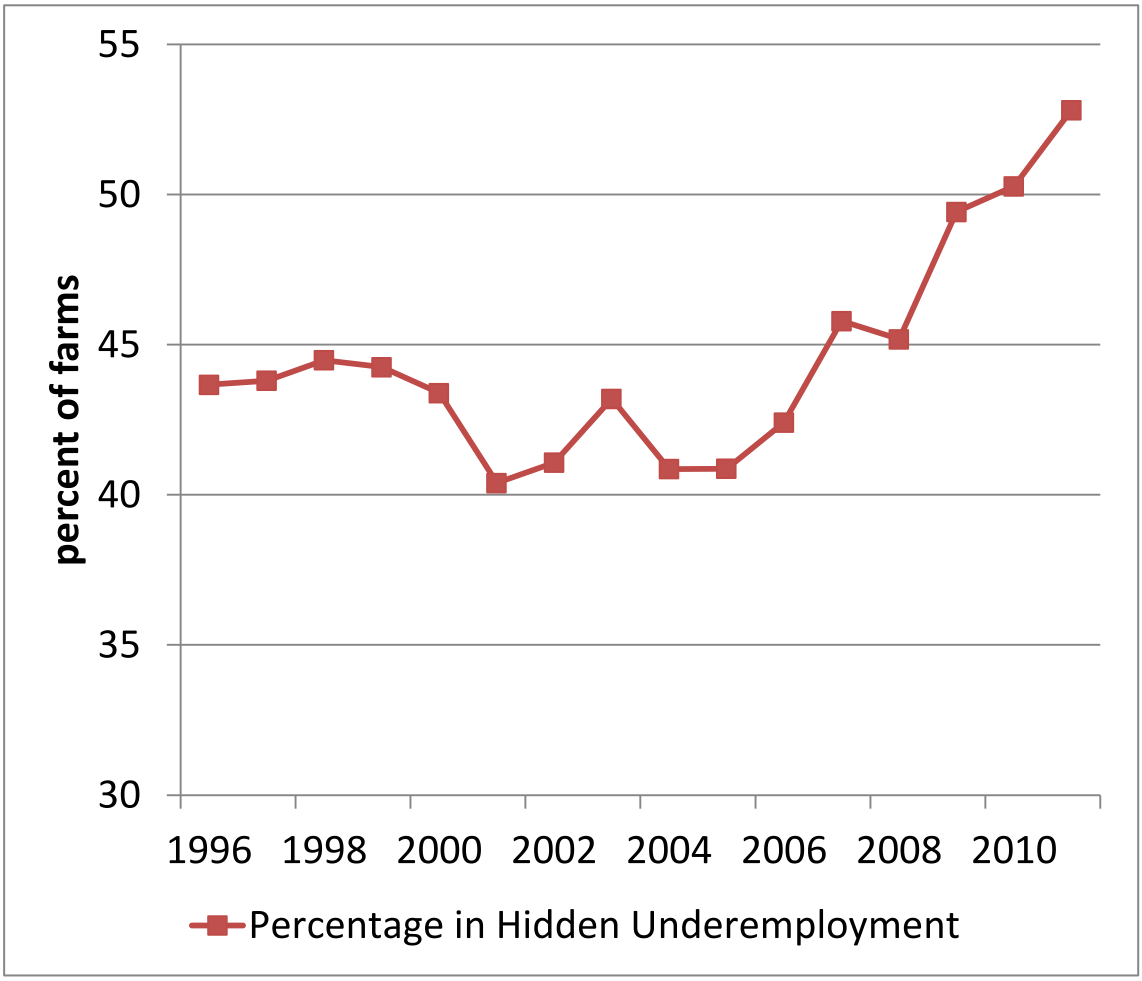


**Figure 5.2 Under-employment rate in Irish agriculture**



## 5.5 FARM LEVEL EMPLOYMENT GROWTH

*Analysis of FH2020 targets*

The analysis of the Food Harvest 2020 targets as published in Laepple et al. (2013) and the Teagasc investment report 2015 starts by estimating the production potential of the existing population of dairy farms. This analysis includes the following assumptions:

- Structural change continues in the dairy farm sector and the number of farms declines
- Output per cow increases by 12% between 2013 and 2020
- Remaining farms specialise by increasing the stocking rate on the dairy platform to 2.6 livestock units per hectare
- This leads to a reduction in total livestock units on some farms and an increased specialisation of labour in dairying

Table 5.9 presents estimates of the impact of achieving the Food Harvest 2020 targets on labour employed on dairy farms

**Table 5.9 Labour Use from 2013 NFS and estimated for Food Harvest 2020**

| | **2013 (NFS)** | **2020** |
|---|---|---|
| Dairy Farms | 18,124 | 15,646 |
| Total Dairy Cows | 1,178,140 | 1,442,002 |
| Total Deliveries | 5,927,647,994 | 7,484,388,370 |
| Total Labour units (incl paid labour) | 29,186 | 28,818 |
| Avg cows per labour unit | 40 | 50 |
| Production increase relative to FH2020 base | | +44% |

- To achieve a 50% increase in dairy volume production, new entrants are required to supply the additional 308 million additional litres. Assuming a start–up unit of 65 cows per labour unit this leads to an additional 826 labour units.
- However, new entrants displace other enterprises. To produce the additional 308 million litres of milk approximately 21,485 hectares of land must move out of livestock or tillage and into dairy.
- Across livestock and tillage the labour to land ratio is on average 0.023 labour units per hectare of land.
- In other words 1 hectare of land moving out of tillage/livestock and into dairy results in a net increase in labour of 0.017 labour units per hectare.
- The new entrants will result in a loss of 490 labour units or a net gain of 336
- The labour employed on existing farms in 2020 (28,818) along with the net gain of 336 leads to a total labour force of 29,155 or a gain of just 31 labour units over the 2013 level.

*Analysis of FW2025 Scenarios*

- Production on existing dairy farms is saturated at the 50% increase limit therefore it is assumed that all additional production is delivered by new entrants
- Assuming an operation that has 65 dairy cows to the labour unit, 5,750 litres per cow and 2.6 cows to the hectare. (modest assumptions on productivity)

- Each 1 percent increase in production over and above the FH2020 target would require 13,500 cows, 209 labour units and 5,421 hectares of land. **This would results in a loss of 124 labour units on beef/tillage farms and so the net gain in employment on the farm level is 85 labour units for every 1% increase over the 2020 targets**

Table 5.10 indicates an increase in Dairy sector jobs of 199 in the base scenario and 2,489 under the base+ scenario

**Table 5.10 Teagasc NFS based Dairy Sector Employment Growth**

| | 2013 | 2020 | 2025 Base | 2025 Base+ |
|---|---|---|---|---|
| Dairy farms | 18,124 | 15,646 | | |
| Total Dairy Cows | 1,178,140 | 1,442,002 | | 1,417,217 |
| Total Deliveries | 5,927,647,994 | 7,484,388,370 | 7,983,420,000 | 10,000,000,000 |
| Ratio relative to 2013 | | | 1.07 | 1.34 |
| Extra labour units | | | 566.75 | 2,856.97 |
| Total Labour units (incl paid labour) | 29,186 | 28,818 | 29,385 | 31,675 |
| Avg cows per labour unit | 40 | 50 | 50 | 50 |
| Production increase relative to FH2020 base | | 44% | | |
| Net change in FTE's | | | 199 | 2,489 |

For non-dairy sectors we undertook an econometric study of the marginal employment elasticity, reported in Table 5.11; the proportional change in employment relative to a proportional change in output. Reflecting the level of under-employment observed in the agriculture and in particular the drystock sector, we find no significant relationship between change in output volume and change in labour on farm over time. As a result in our overall scenario, we assume that any changes in volume output on drystock farms will have no employment impact. The elasticity for tillage farms is positive and significant, but relatively low.

By way of comparison with the farm level simulation described above, we also undertook an econometric analysis of the dairy sector. As there was no substantial variation due to flat volume production, we observe no significant relationship with employment from the historic data. However, we do observe a significant and positive, but low elasticity during the early growth phase since 2010.

**Table 5.11 Farm Level Marginal Employment Elasticities**

| Sector | Elasticity | SE | p | Signif |
|---|---|---|---|---|
| Cattle | 7.7% | 15.1% | 60.9% | No |
| Sheep | 0.6% | 2.2% | 79.5% | No |
| Tillage | 22.9% | 12.8% | 7.4% | Yes |
| | | | | |
| Dairy | -10.6% | 9.4% | 26.0% | No |
| Dairy post 2010 | 4.9% | 2.9% | 9.4% | Yes |

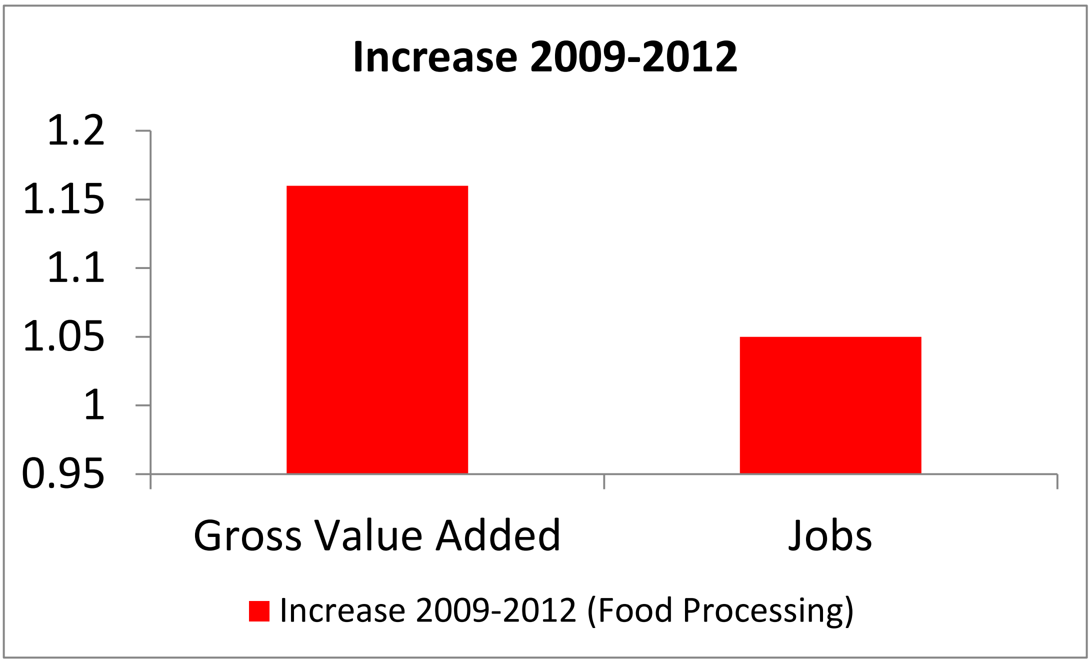
### 5.6 PROCESSING SECTOR EMPLOYMENT ELASTICITIES

In this section we report the methodology used to develop employment elasticities, the proportional change in employment relative to a proportional change in output.

By way of context in Figure 5.3, we report the change in employment since the lowest point of the crisis relative to the change in GVA. We note that GVA increased by 16% in money terms, while hobs increased by 5%, an elasticity of about 0.3. Thus employment increased at only about one third of the increase in GVA or output. This is as a result of

- Spare Capacity
- Capital Investment
- Expansion by businesses with High Productivity
- GVA grew due to prices not only volume

**Figure 5.3 Employment Growth in Food Processing Sector 2009-2012**




In Table 5.12, we report the marginal employment elasticities for the different sub-sectors as well as the Food Processing sector and the component sub-sectors, based upon data from 1978 to 2012, adjusted for CPI. We note that the estimated elasticity for the overall food processing sector is 0.304, remarkably similar to that observed in Figure 5.3 above.

Disaggregating we see a relatively large variability from Seafood Processing which has a high elasticity approaching the assumptions used in standard Input-Output modelling, to relatively low elasticities in the bakery sector.

It should be noted that certain sectors such as the dairy sector have exhibited limited output volume changes over time due to milk quota. As a result of this lack of variation, the econometric approach does not produce significant estimates. In this case, we have used average food processing sector elasticities as a proxy.

**Table 5.12 Processing Level Marginal Employment Elasticities for the Food Processing Sector**

| | |
|---|---|
| Food Processing Sector | 0.304 |
| | |
| Meat and Meat Products | 0.165 |
| Seafood Processing | 0.998 |
| Fruit and Vegetables | 0.577 |
| Vegetable, Animal oils and fats | 0.304 |
| Dairy Products | 0.304 |
| Grain mill products, starches and starch products | 0.304 |
| Bakery and Farinaceous Products | 0.077 |
| Other Food Products | 0.575 |
| Prepared Animal Feeds | 0.093 |
| Beverages | 0.721 |

## 5.7 EMPLOYMENT GROWTH

Applying the output shock to the Leontief Inverse Matrix produced in the Bio-Economy Input-Output Model and then to the marginal employment elasticities for each of our 2 scenarios and 3 sub-scenarios, we produce in Table 5.13 an estimate of the employment creation impact of achieving the meat and animal based growth scenarios.

It should be noted that the employment multiplier is quite sensitive to the choice of methodology. Using average employment to output ratios when combined with the Input-Output model multipliers produce the highest employment forecast for the scenarios modelled. However it is unlikely that this scenario is realistic as typically employment growth rises at a lower rate than output growth due to for example, expansion occurring amongst the most productive companies/farms, under-employment, productivity growth etc.

Considering instead the marginal employment multiplier and elasticity upon which it is based; in other words the proportional change in employment relative to the proportional change in output, based upon historical econometric estimates, we find too that the method is sensitive to specification. Because of this sensitivity, we report two estimates, one based upon an analysis undertaken by the authors below and the second based on Miller et al. (2014). The latter it should be noted has passed through a peer review process and were the basis of the previous estimates. In our analysis below, we find that if the same multipliers are used that the two models, BIO and IMAGE used by Miller et al. (2014) produce remarkably similar results given the differences in methodology employed.

The Miller et al. (2014) multipliers result in employment estimates that lie between the marginal estimates produced in this paper and the average estimates.

In total the base case scenario is simulated to generate 6,329, 15,376 and 11,216 jobs for O'Donoghue Marginal Elasticities, Miller Marginal Elasticities and O'Donoghue Average Elasticities, while the Base+ scenario is simulated to generate respectively 11,216, 23,176 and 38,055 jobs. In both cases, most jobs are generated elsewhere in the value chain, outside the farm gate. Within the primary sector most of the employment growth is generated in the dairy sector, which has relatively little under-employment. Additional employment is generated within the feed sectors as a result of the significant marginal elasticity. About a 30-50% of the total employment would be generated at the processing scale.

The employment numbers are based upon the 162,800 employees working in the food value chain as identified in the 2014 CSO Quarterly National Household Survey.

In terms of the sub-scenarios, dairy growth scenario generates about two thirds of the total employment growth in both the Base and Base+ scenarios.

**Table 5.13 Employment Growth as a result of achieving Food Wise 2025 Scenarios**

| Model | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 |
|---|---|---|---|---|---|---|
| Average/Marginal | Marginal | Marginal | Average | Marginal | Marginal | Average |
| Elasticity | O'Donoghue et al. (2015) | Miller et al. (2014) | O'Donoghue et al. (2015) | O'Donoghue et al. (2015) | Miller et al. (2014) | O'Donoghue et al. (2015) |
| Scenario | Base | Base | Base | Base+ | Base+ | Base+ |
| Jobs | 6,329 | 15,376 | 24,818 | 11,216 | 23,176 | 38,055 |
| Animal and Grassland | 1,081 | 7,373 | | 2,523 | 11,762 | |
| Other Primary Sector | 323 | 81 | | 906 | 129 | |
| Processing Sector | 2,034 | 7,055 | | 3,805 | 9,996 | |
| Other Sectors | 2,629 | 867 | | 3,983 | 1,289 | |

In Table 5.14, we compare the employment per €m of GVA for the simulation scenarios based upon marginal employment elasticities of the Base and Base+ case. Reflecting the fact that the marginal elasticity is about 30% of the average elasticity, we find that the employment multiplier of 22.5% and 29.7% for Base and Base+ scenarios respectively, fall within a plausible estimate, giving us confidence in the overall robustness of our estimates.

**Table 5.14 Validation of Employment Multipliers**

| Scenario | Total Jobs per €m GVA |
|---|---|
| Base | 2.96 |
| Base+ | 3.90 |
| Economy Average | 13.14 |

## 5.8 Understanding the differences between the FH2020 and FW2025 employment impacts

In this section, we attempt to understand the differences between the employment impacts of FH2020 developed by Miller et al. (2014) and FW2025 developed in this paper.

*Restructuring of the Input-Output Table (NACE Rev.1 to Rev.2)*

The original 2005 Input-Output table's sectoral classifications (53x53) are based on the NACE Rev.1 industrial classifications. However, this system of industrial classification has since been updated to NACE Rev.2 with the result that the Input-Output table for 2010 has seen significant restructuring, expanding to a 58x58 classification. Some sectors have been removed entirely and absorbed elsewhere while other sectors are appearing for the first time. Almost all sectors have experienced some definitional changes since 2005 with some significant changes experienced in the tertiary (services) sector. This means that while the narrative description of some sectoral classifications in both the 2005 and 2010 models may be similar, direct comparisons are not appropriate in a number of instances.

In relation to the disaggregation of the Agri-Food sectors, the 2010 model supplies a significantly higher level of disaggregation in the primary sector (28 sectors) than the 2005 model (14 sectors). Additionally, in terms of the Agri-Food processing sectors, the 2005 model reports separate figures for Beef, Pig, Poultry and Sheep processing while the 2010 model reports aggregate figures for the meat processing sector as a whole.

Overall, the output and employment impacts modelled for achieving FH2020 from the 2005 Input-Output Table were constructed by expanding the original 53x53 industry classification to a 75x75 disaggregation. For the 2010 Bio-Economy Input-Output model, the new 58x58 classification has been expanded to a 104x104[10] disaggregation. This necessarily has the effect of reducing the amount of direct comparisons that can be made with the 2005 model in terms of changes in output and employment.

Nevertheless the difference between the output multiplier for the two models as identified in Table 5.15 is remarkably similar.

**Table 5.15 Output Multipliers in the IMAGE and BIO models**

| | **2008 Model** | **2010 Model** | **Ratio** | |
|---|---|---|---|---|
| | IMAGE | BIO | | |
| **Primary** | | | | |
| | | | | |
| Dairy | 1.928 | 1.93 | 1.00 | |
| Cattle | 2.494 | 2.51 | 1.01 | |
| Sheep | 2.333 | 2.197 | 0.94 | |
| Pig | 2.003 | 2.721 | 1.36 | |
| Pol | 1.881 | 2.864 | 1.52 | |
| Cereal | 2.545 | 1.594 | 0.63 | |
| Fruit and Veg | 2.118 | 1.144 | 0.54 | |
| Potato | 1.849 | 1.144 | 0.62 | |
| Other Cereal | 1.856 | 1.482 | 0.80 | |
| Fodder Crops | 1.775 | 1.856 | 1.05 | Winter Forage Own |
| | | 1.679 | | Silage own |
| | | 1.853 | | Hay Own |
| Forestry | 2.684 | 2.199 | 0.82 | |
| Fish | 1.807 | 1.766 | 0.98 | Commercial Fishing |
| | | 2.266 | | Aquaculture |
| **Processing** | | | | |
| Beef | 3.369 | 2.401 | 0.71 | Meat |
| Pig | 2.373 | 2.401 | 1.01 | |
| Poultry | 2.358 | 2.401 | 1.02 | |
| Sheep | 2.463 | 2.401 | 0.97 | |
| Fish | 2.089 | 2.118 | 1.01 | |
| Fruit and Veg | 2.474 | 1.994 | 0.81 | |
| Dairy | 2.405 | 2.213 | 0.92 | |
| Animal Feed | 2.143 | 1.999 | 0.93 | |
| Other Food | 2.032 | 1.751 | 0.86 | |
| | | | | |
| Manufacturing | 2.077 | 1.668 | 0.80 | |
| Services | 1.97 | 1.601 | 0.81 | |

[10] This includes the disaggregated Marine sector

*Jobs per Million*

Differences between the employment to output ratios from the 2005 and 2010 models can be attributed to three primary reasons.

Firstly the use of different data sources in the estimation of total employment for each sector. For the Agri-Food sectors, the 2010 employment data is taken directly from the CIP while the 2005 figures were supplemented with data from Eurostat. We chose to use the former as the CSO's CIP output and input totals are used in the creation of the Input-Output table. There are some significant differences, particularly in the Other Food Products sector that will result in differences.

For the remaining non-Agri-Food sectors, the highly disaggregated employment totals from the Profile 3 - At Work report from the 2011 Census are preferred in order to generate total employment share ratios for each sector which are then applied to the averaged total labour force figures reported for 2010 in the Quarterly National Household Survey.

Secondly, the required changes in labour efficiency as a result of the economic recession have depressed the labour/output ratio for a number of sectors. Thirdly, any improvements in technological efficiency over the timeframe will also depress the labour/output ratio

*Structure and Magnitude of Simulated Output Changes*

In order to compare the impact of the two models IMAGE (Miller et al. 2014) and BIO on which this paper is drawn, we compare the employment impact of the FW2025 scenarios using the same marginal employment multipliers in Table 5.16. Given that both models were developed independently, with different assumptions, data and methods, the fact that the employment targets are within 10% of each other is testament to the robustness of the input-output methodology and the resulting output multipliers.

As a result the main difference between the models is based primarily on the methodology for estimating marginal employment elasticities and multipliers. Part of the reason rests in the fact that there has been relatively little change within the Agri-Food sector over time, with much of the main differences being accounted for by sectoral secular productivity growth. The abolition of milk quota and the volume growth being experienced within the sector at present will allow for greater output and labour variability to be available in future. The precision of the employment multiplier could therefore be improved using better data and methodological developments.

**Table 5.16 A Comparison between FH2020 and FW2025 estimates**

| Model | 2005 | 2005 | 2010 | 2010 |
|---|---|---|---|---|
| Average/Marginal | Marginal | Marginal | Marginal | Marginal |
| Elasticity | Miller et al. (2014) | Miller et al. (2014) | O'Donoghue et al. (2015) | O'Donoghue et al. (2015) |
| Scenario | Base | Base+ | Base | Base+ |
| Jobs | 13,826 | 21,487 | 15,376 | 23,176 |
| Ratio O'Donoghue: Miller | | | 1.11 | 1.08 |

# Chapter 6. THE ECONOMIC IMPACT OF ACHIEVING THE HARNESSING OUR OCEAN WEALTH TARGETS

Eoin Grealis, Amaya Vega, Cathal O'Donoghue, Stephen Hynes

## 6.1 INTRODUCTION

There is substantial agreement in the recognition of Ireland's ocean as a national asset, with vast potential for the further exploitation of Ireland's marine sectors and their contribution to economic growth in the aftermath of the recent recession. Since the publication of the EU Integrated Maritime Policy (IMP) in December 2007, the importance of marine resources for economic development has risen into prominence among EU Member States, including Ireland. The marine sectors that make up the 'blue economy' have the potential to provide 7 million jobs in Europe by 2020 (COM, 2013). Harnessing Our Ocean Wealth – An Integrated Marine Plan for Ireland (HOOW-IMP)[11] is the Irish government's response to the EU-IMP''s call to all Member States to develop their own national integrated maritime policies, which are based on the recognition that *all matters relating to the sea are interlinked and should be dealt with as a whole* (COM(2008) 395 final). Marine socio-economic data is essential to inform marine policy and strategic decision making. There is a need for the establishment of a sustainable methodology for marine socio-economic data collection and analysis that can be constantly updated and refined.

General trends in the economy are inevitably reflected in the ocean economy. Ireland's ocean economy has been impacted by the adverse economic circumstances Ireland experienced during the economic recession and the slow economic recovery that is taking place in recent years. Table 6.1 shows the turnover, GVA and employment trends in Ireland's ocean economy from 2007 to 2014. Ireland's ocean economy had a turnover of €4.2 billion in 2012, of which €1.3 billion was direct GVA. Estimates suggest that turnover from the ocean economy has returned to pre-recession levels, reaching €4.5 billion in 2014 (Vega, A., Hynes, S. and O'Toole, E., 2015). The GVA from Ireland's ocean economic activity was approximately 0.7% of Gross Domestic Product (GDP) in 2012, representing a steady trend since 2007. The Irish ocean economy employed approximately 17,425 individuals in 2012. This represents a 5% increase on 2010 levels. Estimates for 2014 suggest that while some degree of recovery has had an impact on jobs, employment levels are still below pre-recession figures (Vega, A., Hynes, S. and O'Toole, E., 2015).

[11] Government of Ireland, Inter-Departmental Marine Coordination Group (MCG), Harnessing Our Ocean Wealth – An Integrated Marine Plan (IMP) for Ireland.

**Table 6.1 Irish Ocean Economy key figures and trends, 2007, 2010, 2012 and 2014 (e)***

| | 2007 | 2010 | 2012 | % Change 2010-2012 | 2014 (e) | % Change 2012-2014 (e) |
|---|---|---|---|---|---|---|
| **GVA** | €1.7 billion | €1.2 billion | €1.3 billion | 9.2% | €1.4 billion | 8.2% |
| **% GDP** | 0.8% GDP | 0.7% GDP | 0.7% GDP | 4.3% | 0.8% GDP | 3.1% |
| **Turnover** | €4.4 billion | €3.1 billion | €4.2 billion | 33.1% | €4.5 billion | 7.6% |
| **Employment** | 19,938 FTEs | 16,614 FTEs | 17,425 FTEs | 4.9% | 18,480 FTEs | 6.1% |

*Figures for 2014 are estimates (e)

Table 6.2 presents the sector-by-sector percentage change in turnover, GVA and employment from 2007 to 2012. The figures show the effect that the economic crisis had on the ocean economy, with overall negative rates witnessed for all three indicators in the period 2007-2010. The 2010-2012 percentage change figures show that the economic recovery that Ireland has experienced in most recent years is also having an effect on the ocean economy. Turnover in the established marine industries rose from €2.98 billion to €3.96 billion in the period 2010-2012. This represented a 33% increase, which was driven by shipping and maritime transport, sea fisheries, seafood processing, marine manufacturing, construction and engineering and marine retail services. This contrasts with the overall decline in activity recorded for the 2007-2010 period. Employment in the established industries category rose from 15,593 in 2010 to 16,271 in 2012, an increase of 4%. The turnover of firms in the emerging marine industries also increased from €151 million to €215 million in the period 2010-2012, an increase of 42.6%. Employment in the emerging industries category experienced an increase of 13%, while GVA increased by 64%.

Estimates for 2014 suggest that Ireland's economic recovery, characterised by a strong net export growth and a gradual increase in domestic demand, will continue to be reflected in the ocean economy (Vega, A., Hynes, S. and O'Toole, E., 2015). Overall, Ireland's ocean economy is performing on average better than the general economy. While growth in Irish GDP from 2010 to 2012 was approximately 5%, the ocean economy grew by 9% in the same period. Estimates suggest that GVA growth rates in Ireland's ocean economy for the 2012-2014 period are approximately 6%, which is above the 5% estimated increase in Ireland's GDP for the same period (Vega, A., Hynes, S. and O'Toole, E., 2015).

**Table 6.2 Percentage change in turnover, Gross Value Added and employment by sector, 2007-2012.**

| | Turnover (€ 000s) % Change | | GVA (€ 000s) % Change | | Employment (FTE) % Change | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | 2007-2010 | 2010-2012 | 2007-2010 | 2010-2012 | 2007-2010 | 2010-2012 |
| ***Established Markets*** | | | | | | |
| Shipping and Maritime Transport | -34.98% | 58.02% | -31.33% | 8.16% | -21.26% | -3.84% |
| Marine Tourism and Leisure | -23.49% | -10.77% | -25.57% | -23.56% | -5.81% | -5.49% |
| Marine Retail Services | -41.48% | 118.75% | -33.76% | 18.21% | -12.20% | 188.89% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sea Fisheries | -34.78% | 47.53% | -6.89% | 90.79% | -5.27% | 7.15% |
| Aquaculture | 15.89% | 6.37% | 9.27% | 31.17% | -10.27% | 0.42% |
| Seafood Processing | -1.51% | 32.06% | -9.29% | 23.06% | -24.11% | 15.95% |
| Oil and Gas Exploration and Production | -36.26% | 4.71% | -55.38% | -8.04% | -54.56% | 40.95% |
| Marine Manufacturing Construction and Engineering | -58.22% | 25.06% | -60.15% | -20.68% | -54.63% | 15.15% |
| **Established Markets Sub-Total** | -29.13% | 32.58% | -29.98% | 5.75% | -18.44% | 4.35% |
| ***Emerging Markets*** | | | | | | |
| High Tech Marine Products & Services | 28.21% | 27.45% | -23.78% | 85.57% | 11.71% | 7.42% |
| Marine Commerce | -47.11% | 61.49% | -33.74% | 54.56% | 4.76% | 46.36% |
| Marine Biotechnology & Bio products | 5.72% | 49.03% | -5.59% | 44.38% | 15.15% | 22.70% |
| Marine Renewable Energy | 85.61% | 12.20% | -17.35% | 93.89% | 113.86% | -7.41% |
| **Emerging Markets Sub-Total** | -15.88% | 42.64% | -25.92% | 64.04% | 24.51% | 13.03% |
| | | | | | | |
| Total | -28.6% | 33.1% | -29.8% | 9.2% | -16.7% | 4.9% |

### 6.2 HARNESSING OUT OCEAN WEALTH – AN INTEGRATED MARINE PLAN FOR IRELAND

In 2007, the European Commission published the “Blue Book”, an Integrated Maritime Policy for the European Union (IMP-EU) (COM (2007)575 final). The IMP-EU seeks to provide a more coherent approach to maritime issues and it covers a number of cross-cutting policies including blue growth, the EU strategy to support sustainable growth across marine and maritime sectors and sea basin strategies. In this regard, the IMP-EU regional approach recognises the unique needs of each of Europe’s seas and oceans. As a result, the European Union Atlantic Strategy was adopted by the European Commission in 2011, which was of special interest to Ireland and the other four Atlantic Member States: Spain, Portugal, France and the UK. The strategy identifies challenges and opportunities in the Atlantic region and it also identifies the existing initiatives to support growth and job creation in the Atlantic region, in line with the objectives of the IMP-EU. The EU Atlantic Strategy is implemented through the Atlantic Action Plan (COM, 2013), which was adopted by the Commission in 2013. The Atlantic Action Plan encourages the Atlantic Member States to collaborate in sharing information, costs and best practices under four main priorities: (1) to promote entrepreneurship and innovation; (2) to protect, secure and enhance the marine and coastal environment; (3) to improve accessibility and connectivity; and (4) to create a socially inclusive and sustainable model of regional development. Priority four of the Atlantic Action Plan calls for the development of *appropriate and usable marine socio-economic indicators* *to measure, compare and follow trends in the development of the blue economy* (COM, 2013).

Harnessing Our Ocean Wealth – An Integrated Marine Plan for Ireland (HOOW-IMP) is the Irish government's response to the IMP-EU's call to all Member States to develop their own national integrated maritime policies, which are based on the recognition that *all matters relating to the sea are interlinked and should be dealt with as a whole* (COM(2008) 395 final). Published in 2012, HOOW-IMP presents *the Government's vision, high-level goals and integrated actions across policy, governance and business to enable Ireland's marine potential to be realised* (Government of Ireland, 2012).

In HOOW-IMP, the Irish government sets the overarching targets to double the value of Ireland's ocean economy to 2.4% of GDP by 2030 and to increase the annual turnover to exceed €6.4bn by 2020. This is obtained from a range of individual sectoral targets as shown in Table 6.3.

**Table 6.3 Sectoral targets set out in the Integrated Marine Plan**

| Sector | Ocean Wealth 2020 Target* |
|---|---|
| Seafood (fisheries, aquaculture, seafood processing) | €1,000 million |
| Maritime Commerce and Ship Leasing | €2,600 million |
| Marine and Coastal Tourism and Leisure (including Cruise Tourism) | €1,500 million |
| Marine ICT and Biotechnology | >€61 million |
| Ports and Maritime Transport Services, Maritime Manufacturing, Engineering, Offshore Oil and Gas, other marine industries | >€1,200 million |

Source: Harnessing our Ocean Wealth – An Integrated Marine Plan for Ireland; *Projected Annual Turnover by 2020. Baseline period: 2007

It is thus viewed that the successful expansion of Ireland's ocean economy can make a valuable contribution to economy recovery in the post-recession era. However, the full effects of this expansion are not known. As discussed in previous chapters, in contrast to more globalised economic activity, the nature of the Bio-Economy is such that it has a permanent link to the domestic economy and typically relies on a greater proportion of locally sourced inputs and higher levels of labour. The indirect impacts of expansion in the marine sector may exceed the indirect impacts of expansion in other areas of the economy. In the face of competing resources and public policy focus, there is a requirement to understand the full impacts both direct and indirect, of achieving the HOOW targets.

## 6.3 DATA

CSO supplies a number of data sets that provide information on turnover, GVA and employment for all production sectors in the Economy. The CSO census and surveys which provide data on Ireland's ocean economy include the CIP, 2007-2012, the ASI, 2007-2012, BCI, 2007- 2012 and Intrastat, 2007-2012. Marine activities can be fully or partially marine activities. In the latter case, proxies are used to identify the percentage of marine in these activities (see Vega et al., (2015) for more details).

In this chapter, the Bio-Economy Input-Output model outlined in earlier chapters is used to study the relationship between Ireland's marine sectors and the rest of the economy in order to estimate the potential direct and indirect macroeconomic impact of increases in output across a number of key strategic marine sectors.

The HOOW strategy outlines a number of targets for the Marine Sector, specifically a €1bn target for Seafood, €2.6bn for Maritime Commerce and Ship Leasing, €1.5bn for Marine and Coastal Tourism and a €1.2bn target for Ports and Maritime Transport Services, Maritime Manufacturing, Engineering, Offshore Oil and Gas and other marine industries. This results in a total of €6.3bn for the Marine sector. There is an additional target of achieving greater than €61m of output set for the emerging Marine ICT and Biotechnology sector (bringing the headline total to €6.4bn) however this is not considered in this analysis and there was not sufficient information to disaggregate this sector in the Bio-Economy Input Output table. While the four individual HOOW targets are instructive, they do not provide sufficient information to identify specific targets for the 8 sector Marine disaggregation defined in the model necessitating a number of assumptions.

Firstly, the €1bn target for seafood has been applied pro-rata on the basis of output to the Fishing, Aquaculture and Seafood Processing sectors with required increases of €242m, €181m and €577m applied to the model. These figures are summarised in Table 6.4

**Table 6.4 Apportionment of HOOW Seafood Targets**

| | Seafood | Fishing | Aquaculture | Seafood Processing |
|---|---|---|---|---|
| Output €m | 676 | 164 | 123 | 390 |
| HOOW Target €m | 1,000 | 242 | 181 | 577 |
| **Required Increase €m** | **324** | **79** | **59** | **187** |

Secondly, the €2.6bn target for Maritime Commerce and Ship Leasing and the €1.2bn target for Ports and Maritime Transport Services etc. and other marine industries have been combined for a target of €3.8b and applied pro-rata across the Oil & Gas, Marine Manufacturing, and Engineering & Construction, Marine Retail and Shipping and Transport sectors. These figures are summarised in Table 6.5

**Table 6.5 Apportionment of HOOW Maritime Commerce and Transport Targets**

| | Maritime Commerce and Transport | Oil &Gas | Marine Manu, Eng & Const. | Marine Retail | Shipping and Transport |
|---|---|---|---|---|---|
| Output €m | 1,566 | 126 | 111 | 58 | 1,272 |
| HOOW Target €m | 3,800 | 305 | 269 | 140 | 3,086 |
| **Required Increase €m** | **2,234** | **179** | **158** | **82** | **1,814** |

Finally, the Marine and Coastal Tourism target of €1.5bn remains unchanged with the existing base year value of €723m giving a required increase of €777m.

## 6.4 RESULTS

*Output*

Table 6.6 shows the results for the estimation of the total economic impact of reaching the HOOW targets detailed in the previous section. Individual output multipliers for each of the disaggregated marine sectors in the Bio-Economy Input Output model are estimated. Overall, this results in an estimated direct impact of €3.3bn on the 2010 base year with an additional indirect effect of €2.7bn million in the wider economy, giving a total impact of over €9bn. Table 6.6 shows the breakdown of this figure by each sector, with the largest additional indirect effect coming from Shipping and Transport, followed by Marine Tourism.

**Table 6.6 Total Economic Impact of Reaching the HOOW Targets**

| | Fishing | Aquaculture | Oil &Gas | Seafood Processing | Marine Manu, Eng & Const. | Marine Retail | Shipping and Transport | Marine Tourism | Total €M |
|---|---|---|---|---|---|---|---|---|---|
| Output Multiplier | 1.40 | 1.41 | 1.57 | 1.65 | 1.74 | 1.50 | 2.01 | 1.60 | - |
| 2010 Output €m | 164 | 123 | 126 | 390 | 111 | 58 | 1,272 | 723 | 2,965 |
| Required €m | 79 | 59 | 179 | 187 | 158 | 82 | 1,814 | 777 | 3,335 |
| **HOOW Target €m** | **242** | **181** | **305** | **577** | **269** | **140** | **3,086** | **1,500** | **6,300** |
| Indirect Impact €m | 31 | 24 | 101 | 122 | 118 | 41 | 1,841 | 468 | 2,745 |
| **Total Impact €m** | **273** | **205** | **407** | **697** | **386** | **181** | **4,927** | **1,968** | **9,045** |

Table 6.7 reports the distribution of that indirect output in terms of primary, manufacturing and service sectors for each marine sector. The service sector experiences the greatest indirect impact across all sectors with the exception of the Seafood Processing sector, due to the higher proportional reliance on inputs from primary production in the form of feed and juveniles. As anticipated, the Shipping and Transport generates the largest share of indirect output mainly focused in the Services sector due to high demand for fuel, warehousing services, and supporting administrative services.

**Table 6.7 Distribution of Indirect Output in Primary, Manufacturing and Services Sectors (€m)**

| (€m) | Fishing | Aquaculture | Oil &Gas | Seafood Processing | Marine Manu, Eng & Const. | Marine Retail | Shipping and Transport | Marine Tourism | Total €M |
|---|---|---|---|---|---|---|---|---|---|
| Primary | 0 | 7 | 18 | 70 | 0 | 0 | 10 | 5 | 113 |
| Manufacturing | 12 | 7 | 23 | 25 | 13 | 5 | 203 | 54 | 343 |
| Services | 18 | 10 | 60 | 26 | 104 | 36 | 1,628 | 409 | 2,291 |
| **Total Impact** | **31** | **24** | **101** | **121** | **118** | **41** | **1,841** | **468** | **2,745** |

Table 6.8 presents the ranking of economic sectors in the context of their estimated output multipliers. For convenience, the agricultural sector has been re-aggregated with the exception of the Fishing and Aquaculture sectors. In terms of simulated increased demand in the domestic economy, the disaggregated marine sectors compare favourably when compared with the rest of the economy. Ireland is a small open island economy which is heavily dependent on exported goods and a positive balance of trade. The Shipping and Transport sector is a crucial component of Ireland's capacity to trade internationally and is deeply embedded in almost every other sector in the economy. Consequently, the Shipping and Transport and transport sector is ranked at the top of the classification, with a multiplier of 2.08. Other marine sectors which rank among the top 15 are Marine Manufacturing, Engineering and Construction (1.74), Seafood Processing (1.65) and Marine Tourism (1.60) all of which are relatively more dependent on the consumption of domestic inputs. All sectors with the exception of fishing are classified in the top half of the ranking while as a whole the Bio-Economy Input Output model returns an output multiplier value of 1.76 for the Marine

sector. This illustrates the marine sector's relative embeddedness in the domestic economy in comparison to other sectors.

**Table 6.8 Marine Sectors in Domestic Multiplier Rankings.**

| Sector | Multiplier | Rank | Sector | Multiplier | Rank |
|---|---|---|---|---|---|
| **Marine Shipping & Transport** | **2.08** | **1** | Telecommunications serv. | 1.40 | 34 |
| Other serv. | 1.87 | 2 | **Fishing** | **1.40** | **35** |
| Wood & wood products | 1.85 | 3 | Retail trade | 1.39 | 36 |
| Membership organisation serv. | 1.75 | 4 | Wholesale trade | 1.37 | 37 |
| **Marine Manu Eng & Const.** | **1.74** | **5** | Cultural & sporting serv. | 1.36 | 38 |
| Travel & tourism service activities | 1.74 | 6 | Motor fuel, vehicle trade/repair | 1.34 | 39 |
| Repair of consumer goods | 1.73 | 7 | Pulp, paper/paper products | 1.33 | 40 |
| Construction | 1.70 | 8 | Publishing, film & broadcasting serv. | 1.33 | 41 |
| Land transport serv. | 1.69 | 9 | Basic metals | 1.32 | 42 |
| Other non-metallic mineral products | 1.68 | 10 | Motor vehicles, trailers & semi-trailers | 1.30 | 43 |
| Other professional, scientific serv. | 1.68 | 11 | Machinery & equipment n.e.c. | 1.30 | 44 |
| **Seafood Processing** | **1.65** | **12** | Electricity & gas supply | 1.30 | 45 |
| Scientific research | 1.64 | 13 | Mining, quarrying & extraction | 1.29 | 46 |
| Water transport serv. | 1.60 | 14 | Repair/installation Mach & Equip. | 1.29 | 47 |
| **Marine Tourism** | **1.60** | **15** | Computer consult. /data process. | 1.29 | 48 |
| Legal, Acc, Mang. Consult | 1.58 | 16 | Air transport serv. | 1.29 | 49 |
| Financial intermediation serv. | 1.57 | 17 | Fabricated metal products | 1.29 | 50 |
| **Oil & Gas** | **1.57** | **18** | Printed matter & recorded media | 1.27 | 51 |
| Water collection, treatment, supply | 1.56 | 19 | Education serv. | 1.24 | 52 |
| Other financial activities | 1.53 | 20 | Rubber & plastics | 1.24 | 53 |
| Postal & courier serv. | 1.51 | 21 | Electrical equipment | 1.24 | 54 |
| Rental & leasing serv. | 1.51 | 22 | Textiles | 1.20 | 55 |
| **Marine Retail** | **1.50** | **23** | Security, office & business support serv. | 1.20 | 56 |
| Warehousing | 1.50 | 24 | Human health & social work serv. | 1.20 | 57 |
| Agriculture, forestry & fishing | 1.50 | 25 | Recreation serv. | 1.19 | 58 |
| Insurance, pension funding | 1.49 | 26 | Petroleum; furniture; other manufacturing | 1.18 | 59 |
| Food & beverages & tobacco | 1.48 | 27 | Computer, electronic & optical products | 1.17 | 60 |
| Real estate serv. | 1.47 | 28 | Other transport equipment | 1.16 | 61 |
| Accom. Food & Beverage serv. | 1.45 | 29 | Advertising & market research serv. | 1.15 | 62 |
| Sewerage, refuse serv. | 1.45 | 30 | Employment serv. | 1.13 | 63 |

| | | | | | |
|---|---|---|---|---|---|
| Architectural & engineering serv. | 1.44 | 31 | Basic pharmaceutical products | 1.10 | 64 |
| **Aquaculture** | **1.41** | **32** | Chemicals & chemical products | 1.05 | 65 |
| Public administration | 1.40 | 33 | Private households with employed persons | 1.00 | 66 |

*Gross Value Added*

Table 9 shows the results from the estimation of the economic impact of reaching the HOOW targets on Gross GVA, with the GVA Multipliers corresponding to each of the marine sectors displayed in the first row. Shipping and Transport and Seafood Processing show the largest GVA multipliers across the marine sectors. As anticipated, the lowest GVA multipliers are witnessed in the primary production sectors namely fishing and aquaculture. Overall, this results in an estimated direct impact of €1.24bn of GVA on the 2010 base year with an indirect effect of €1.23bn in the wider economy, giving a total impact of over €2.4bn in additional GVA.

**Table 6.9 Impact on Gross Value Added of Reaching the HOOW Targets**

| (€m) | Fishing | Aquaculture | Oil &Gas | Seafood Processing | Marine Manu, Eng & Const. | Marine Retail | Shipping and Transport | Marine Tourism | Total €M |
|---|---|---|---|---|---|---|---|---|---|
| GVA Multipliers | 1.31 | 1.39 | 1.53 | 2.26 | 2.03 | 1.44 | 2.42 | 1.59 | - |
| Direct Inc. GVA | 0.57 | 0.38 | 0.49 | 0.21 | 0.40 | 0.59 | 0.32 | 0.47 | - |
| Indirect Impact | 45 | 22 | 88 | 38 | 63 | 48 | 576 | 363 | 1,242 |
| **Total Impact** | 14 | 9 | 46 | 49 | 65 | 21 | 816 | 213 | 1,232 |

Table 6.10 reports the distribution of indirect GVA from the Primary, Manufacturing and Services sectors across the marine sectors. As seem previously in relation to output, across all sectors with the exception of Seafood Processing, the largest shares of indirect GVA are created in the services sectors which 86% of the total indirect GVA.

**Table 6.10 Distribution of Indirect Gross Value Added**

| (€m) | Fishing | Aquaculture | Oil &Gas | Seafood Processing | Marine Manu, Eng & Const. | Marine Retail | Shipping and Transport | Marine Tourism | Total (€m) |
|---|---|---|---|---|---|---|---|---|---|
| Primary | 0 | 2 | 11 | 28 | 0 | 0 | 4 | 2 | 48 |
| Manufacturing | 5 | 2 | 10 | 8 | 6 | 2 | 73 | 18 | 125 |
| Services | 9 | 4 | 25 | 12 | 59 | 19 | 738 | 193 | 1,058 |
| **Total Impact** | 14 | 9 | 46 | 49 | 65 | 21 | 816 | 213 | 1,232 |

*Employment*

Table 6.11 reports the employment impact of reaching the HOOW targets across all marine sectors. Employment multipliers are estimated for each sector based on the adjusted existing labour/output ratios calculated for the base year of 2010 from the latest Ireland's Ocean Economy Report and are displayed in the first row. The Bio-economy Input Output model estimates the creation of circa 16,927 indirect jobs, with over 60% of those allocated to Shipping and Transport. The model also predicts that the total employment impact resulting from reaching HOOW targets would be an additional 32,859 jobs.

**Table 6.11 Employment Impact of Reaching the HOOW Targets**

| | Fishing | Aquaculture | Oil &Gas | Seafood Processing | Marine Manu, Eng & Const. | Marine Retail | Shipping and Transport | Marine Tourism | Total |
|---|---|---|---|---|---|---|---|---|---|
| Emp. Multiplier | 1.49 | 1.38 | 2.37 | 2.36 | 1.84 | 1.59 | 2.79 | 1.49 | - |
| Jobs/€M | 12.7 | 7.8 | 2.9 | 4.1 | 6.6 | 4.4 | 3.3 | 7.6 | - |
| 2010 Employment | 2,084 | 952 | 359 | 1,586 | 726 | 252 | 4,137 | 5,497 | 15,593 |
| 2010 Output €m | €164 | €123 | €126 | €390 | €111 | €58 | €1,272 | €723 | €2,965 |
| HOOW Increase €m | €79 | €59 | €179 | €187 | €158 | €82 | €1814 | €777 | €3,335 |
| Direct Jobs | 1,000 | 457 | 512 | 761 | 1,035 | 359 | 5,901 | 5,908 | 15,932 |
| Indirect Jobs | 487 | 173 | 701 | 1,033 | 874 | 212 | 10,567 | 2,881 | 16,927 |
| **Total** | 1,486 | 629 | 1,213 | 1,794 | 1,910 | 571 | 16,467 | 8,789 | 32,859 |

Table 6.12 reports the distribution of indirect jobs from the Primary, Manufacturing and Services sectors across the marine sectors. Again, across all sectors with the exception of Seafood Processing, the largest share of the estimated indirect jobs are created in the services sectors (13,334) which account for 79% of total across all sectors.

**Table 6.12 Distribution of Indirect Employment Impacts of Reaching the HOOW Targets**

| | Fishing | Aquaculture | Oil &Gas | Seafood Processing | Marine Manu, Eng & Const. | Marine Retail | Shipping and Transport | Marine Tourism | Total |
|---|---|---|---|---|---|---|---|---|---|
| Primary | 6 | 61 | 140 | 730 | 2 | 3 | 108 | 72 | 1,122 |
| Manufacturing | 286 | 22 | 126 | 128 | 63 | 22 | 1,578 | 244 | 2,470 |
| Services | 194 | 89 | 435 | 175 | 808 | 187 | 8,881 | 2,565 | 13,334 |
| Tot. Ind. Impact | 487 | 173 | 701 | 1,033 | 874 | 212 | 10,567 | 2,881 | 16,927 |

It should be noted that employment estimates from the Bio-Economy model are based on average employment multipliers and are wholly derived from anticipated changes in output. They should be viewed as an upper bound in the estimation of both the direct and indirect employment impacts of expansion. In reality it is likely that considerable economies of scale will be experienced in the event of large scale expansion in the marine sector and well as increases in productivity with the adoption of improved production methods. Ideally, the estimation of marginal employment coefficients would be a more preferable approach however there is a significant shortfall in the availability of data for the purposes of this estimation. In contrast with the agricultural sector which has over 40 years of annual data on the relationship of employment to output (via the National Farm Survey), relatively, the Ocean Economy series is in it's infancy with only 5 years data available over an 8 year period. In addition, those years bridge the second biggest recession in the state making the elicitation of reliable marginal employment coefficients to estimate the relationship of employment to output extremely difficult. Consistency of measurement, additional detail on the determinants of output at the unit level and additional years of observation will be required in order to facilitate the estimation of more reliable employment multipliers in the future.

### 6.5 Summary and Conclusions

In the context of the Blue Growth strategy and the Blue Economy (COM, 2012; COM, 2014), the support for sustainable growth in Ireland's ocean economy has become a key policy objective in recent years. The importance of Ireland's marine resources as a key asset to contribute to the expansion of the national economy has been recognised in Harnessing Our Ocean Wealth (HOOW) – An Integrated Marine Plan for Ireland, published in July 2012. HOOW sets an overarching target to double the value of Ireland's ocean economy to 2.4% of GDP by 2030 and to increase the annual turnover to exceed €6.4bn by 2020. A number of individual sectoral targets were set out, namely a €1bn target for Seafood, €2.6bn for Maritime Commerce and Ship Leasing, €1.5bn for Marine and Coastal Tourism and a €1.2bn target for Ports and Maritime Transport Services, Maritime Manufacturing, Engineering, Offshore Oil and Gas and other marine industries. In this chapter, the Bio-Economy Input Output model is used to estimate the economic impacts of reaching these targets in terms of output, GVA and employment.

The total economic impact of reaching HOOW targets results in an estimated direct impact of €3.3bn on the 2010 base year with an additional indirect effect of €2.7bn million in the wider economy, giving a total impact of over €9bn. In terms of GVA, results show an estimated direct impact of €1.24bn of GVA on the 2010 base year and an indirect effect of €1.23bn in the wider economy, resulting in a total impact of €2.4bn in additional GVA.

With regard to employment, the Bio-Economy Input Output model estimates the creation of 16,953 indirect jobs. The total employment impact of reaching HOOW targets would result in an additional 32,885 jobs. As previously noted in the chapter, the lack of data in terms of the relationship between employment and output within the ocean economy represents a main constraint in terms of our ability to estimate the direct and indirect employment impacts of the expansion of the Marine Sector in the most reliable manner. Therefore, the reported employment multipliers should be viewed as an upper bound in the estimation of both direct and indirect employment impacts.

Overall, the results from the model illustrate the significant impacts that the expansion of the Marine Sector could have on the wider economy as a result of reaching the HOOW targets. The spatial distribution of these impacts may be the subject of further research. While the regional impacts for seafood sectors (fishing, aquaculture and seafood processing) may be predominantly localised around coastal rural areas, this may not be the case for Shipping and Maritime Transport, which tends to be concentrated around larger urban centres. In any case, the results from the Bio-Economy Input Output model suggest that the indirect impacts of the expansion of Ireland's ocean economy may exceed those found in other non-marine economic sectors. The understanding of both direct and indirect impacts is essential for efficient decision making in public policy, in particular in terms of the allocation of limited resources.

# Chapter 7. THE INVESTMENT IMPACT OF DAIRY SECTOR EXPANSION

Thia Hennessy, Cathal O'Donoghue, Eoin Grealis, and Fiona Thorne

## 7.1 INTRODUCTION AND CONTEXT

It is generally recognised that growth in agriculture is fuelled by investment. This investment can come in numerous forms. It can come in the form of human capital embodied in the farm operator, which can be acquired through education, training, experience and extension. It can also come in the form of improved genetic merit of animals, improved crop varieties and better quality machinery and buildings. Finally investment can also come in the form of additional buildings, machines, livestock and land, commonly referred to as fixed investment. In this chapter we will focus on the latter category of farm investment and provide an estimate of the potential economic impact, both upstream and downstream from the farm as a result of reaching the growth scenarios suggested by the Food Wise 2025 committee for the dairy sector in particular.

It is evident from numerous international literature sources that farmers' ability to access scarce farm assets, and their ability to access attractive terms of financing plays a major role in agricultural development. Hence, it is interesting to examine the ability of farm units to balance net income flows and investment requirements and the potential wider economic impact of such investment in light of policy approaches; such as those laid down by the Food Wise 2025 committee (DAFM, 2015).

In order to address the aforementioned factors, the remaining sections of this chapter are as follows: background section to outline investment and financing capabilities of the dairy farm sector in a sectoral context, international context of dairy farm investment, projected investment needs of the dairy farm sector to support the attainment of Food Wise 2025 growth scenarios, wider economic impacts of the aforementioned farm investment and finally some conclusions from the analysis.

## 7.2 METHODOLOGY: FARM INVESTMENT

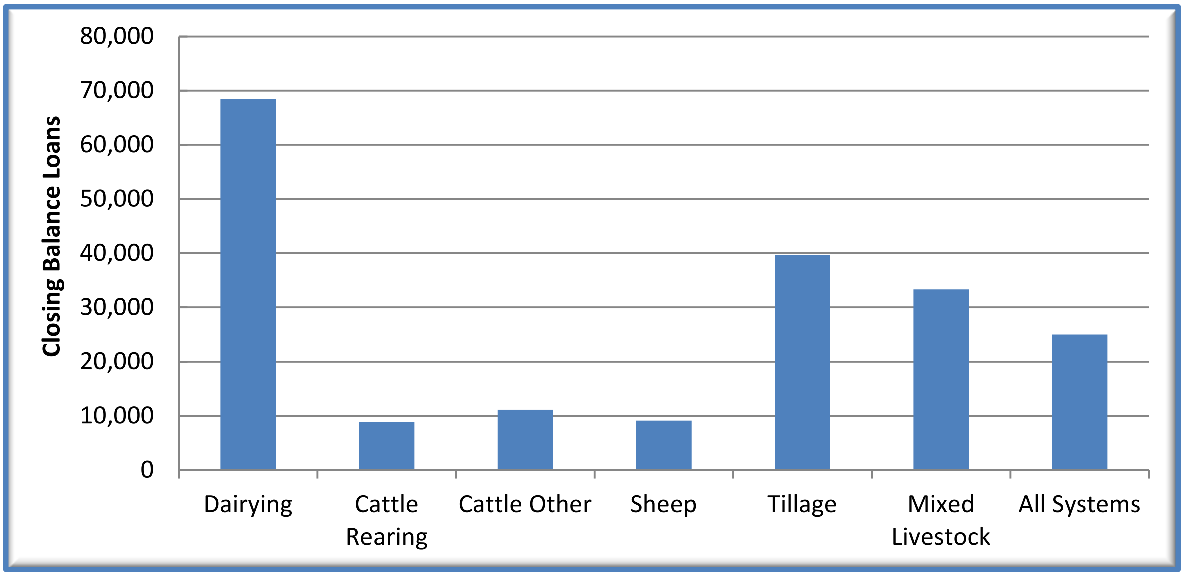
*Background: Financial Status of Irish Farms*

This section provides some background context with a review of the performance of Irish farms in terms of key financial indicators since the year 2002 which creates a focus for this study.

Analysis of Teagasc National Farm Survey (NFS) data, as outlined by Thorne et al., (2015) and Hennessy and Moran (2015), has shown that the average level of debt on dairy (and tillage farms) was significantly higher than on livestock farms over the time period examined (2002-2014).

Figure 7.1 shows that the average level of debt on all farms (farms with and without debt) in 2014 was approx. €25,000, with dairy farms recording the highest level of debt at an average of approximately €68,000 for specialist dairy farms. On the other hand the level of debt on beef and sheep farms was significantly less than that experienced on dairy (and tillage farms).

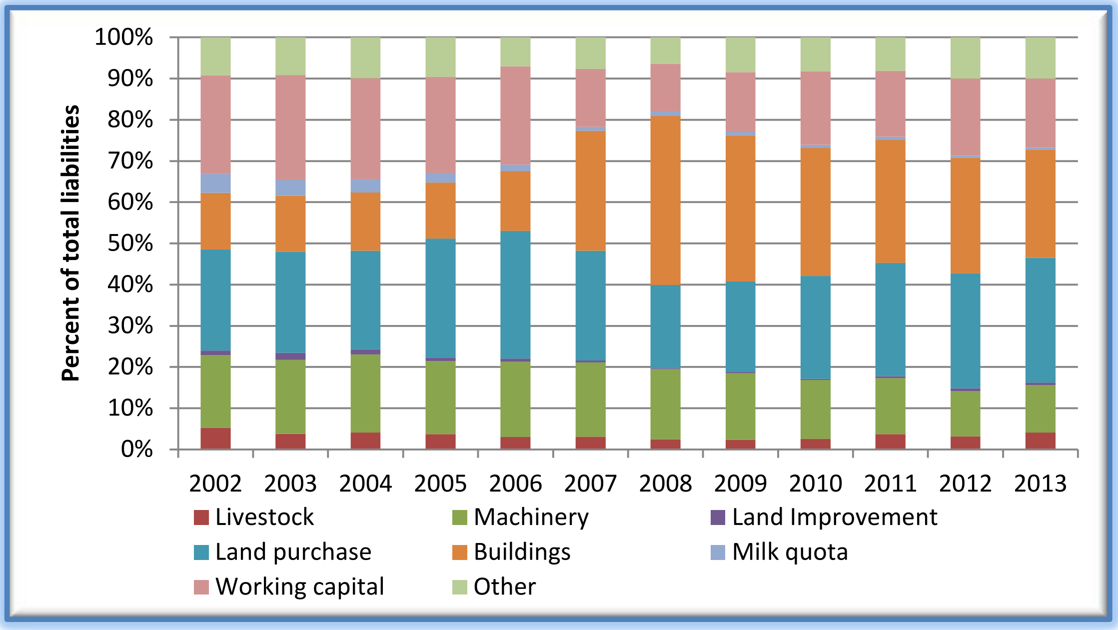
**Figure 7.1 Closing Balance of Loans by Farm System (2014)**




Source: Hennessy and Moran (2015) Teagasc, National Farm Survey

It is also worthwhile to note the purpose for which farm loans have been taken out in recent years. Figure 7.2 shows the proportion of liabilities per loan category with regard to farm loans in recent years, with the majority of loans being used for buildings, land purchase and working capital.

**Figure 7.2 Investment purposes per loan category (2002-2013)**

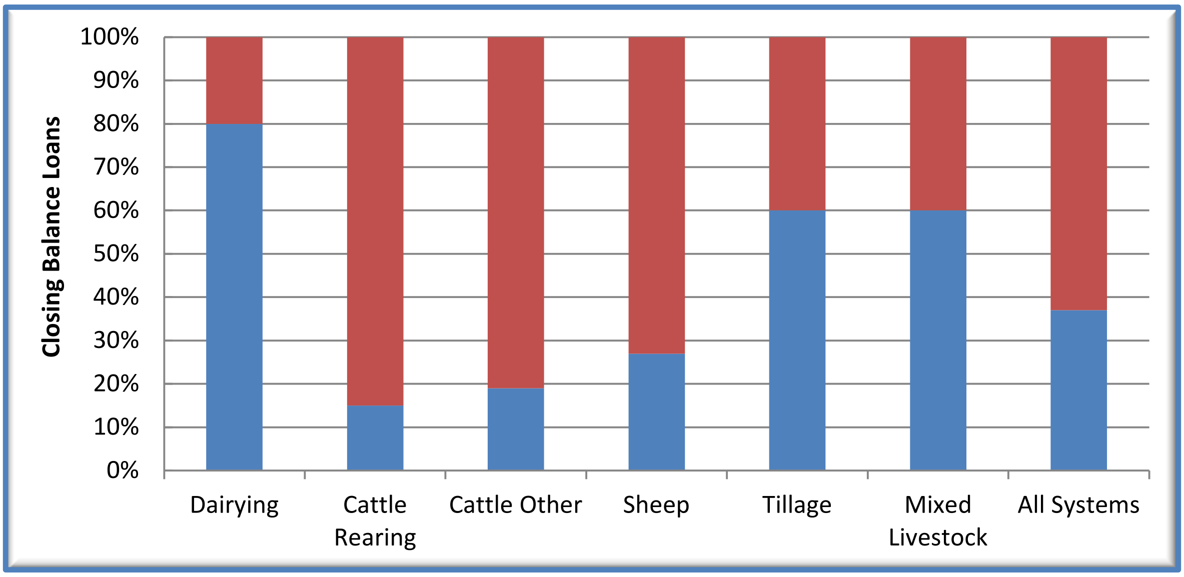



Source: Thorne et al., (2015)

The closing balance of debt on all farms in 2013, as recorded by the Teagasc National Farm Survey, for the 80,000 commercial farms represented by the sample, was approx. €1.9 billion. This aggregate debt figure is not directly comparable with the total debt figures as recorded by the Central Bank for the sector as a whole. The NFS data do not include pig and poultry farms which, although small in number, are generally very large operations and may have significant debt levels. Data on debt recorded in the Teagasc National Farm Survey is confined strictly to farm related debt levels on commercial dairy, drystock and tillage farms. Furthermore, the NFS sample does not typically include farms that have a large-scale farm-related business such as agricultural contracting, food processing or agri-input supply. Such farms are likely to have considerable debt levels which would be reflected in the Central Bank figures but not in the Teagasc NFS data.

Thorne et al., (2015) also showed that there was an increase in liabilities recorded on farms in nominal terms in recent years, but despite the increase the historically low level of debt relative to assets and equity has reaffirmed the farm sector's strong financial position. In financial terms (and ensuing repayment capacity) the dairy sector in particular has remained relatively well insulated from the negative risks associated with commodity production (such as adverse weather), changing macroeconomic conditions in the world economy, as well as any fluctuations in farm asset values that may have occurred due to changing demand for agricultural assets. This financial situation on dairy farms was confirmed by Thorne et al., (2015) and Hennessy and Moran (2015b) by looking at a range of financial health check indicators, with the results of one such indicator, economic viability, reported in Figure 7.3 below. In 2014, 80 percent of dairy farms and 60 percent of mixed livestock and tillage farms were economically viable. Mixed livestock farms typically have a dairy enterprise but are not specialised in dairying. On the other hand, only 15 percent of cattle rearing farms, 19 percent of cattle other farms and just 27 percent of sheep farm businesses are economically viable.

**Figure 7.3 Financial Efficiency Indicator – Economic Viability Assessment by Farm System (2014)**



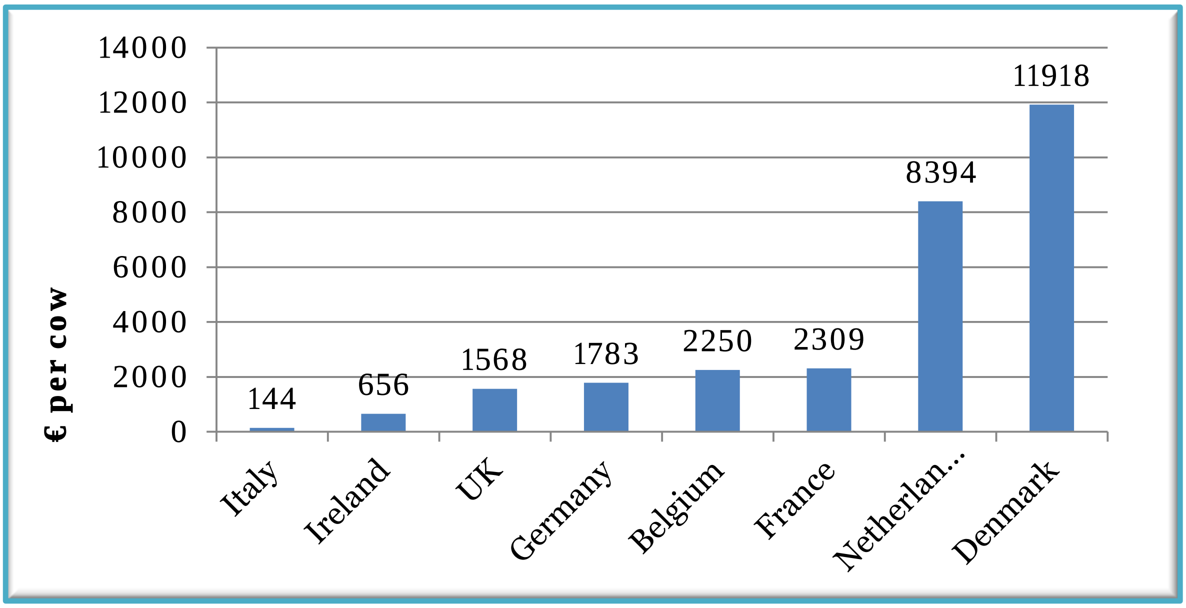

Source: Hennessy and Moran (2015b)

*Comparison of the financial structure of farming in the EU*

Given that Irish agriculture is now competing in an increasingly globalised market place, the financial stability from an inter country perspective (i.e. between competing countries) is very important.

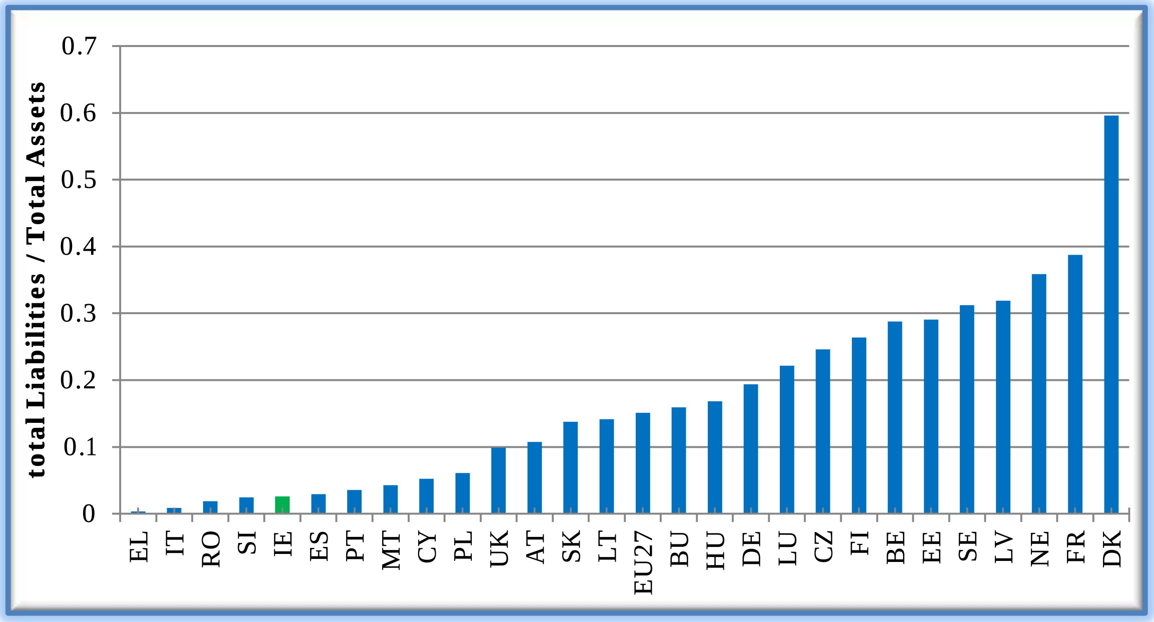
The financial indicators examined in this section used data from the European Commission Farm Accountancy Data Network (FADN). Using data from this source Thorne *et al.*, (2015) indicated that on average Irish farms have relatively low debt and high asset values relative to the EU average for all farms. Furthermore, looking at solvency, liquidity and financial efficiency indicators it is evident that Irish farms are in a very healthy position in EU terms. Figure 7.4 shows the average debt level per cow for a number of important dairy producing regions in the EU while Figure 7.5 shows the average debt/asset ratio across all EU farms.

**Figure 7.4 Average debt level per cow per farm by FADN region in 2012**




Source: DG AGRI EU-FADN.

**Figure 7.5 Average liabilities-to-assets ratio per farm by FADN region in 2012**




Source: DG AGRI EU-FADN.

While previous work by Teagasc (outlined in Donnellan *et al.*, 2011) has shown that Ireland continues to exhibit a healthy position in terms of the competitiveness of its dairy sector (in EU and international markets), in a market which is increasingly exposed to market price volatility, the ability to demonstrate resilience will be equally important in the future. Given that this research has indicated that not only does Irish dairy farming enjoy a competitive advantage in cost terms within the EU, the level of debt and financial status of Irish dairy farms should also provide Irish farms with a relative advantage in resilience terms given that they are not servicing high debt levels in years of extreme market volatility.

*Projected investment needs of the dairy farm sector to reach 2025 Food Wise Growth Scenarios*

Whilst the previous sections of this chapter have indicated the recent positive financial status of Irish dairy farms in particular in a national and EU context it is important to determine what the likely investment needs might be in the future given current policy objectives such as the Food Wise 2025 report (DAFM 2015).

The Food Wise 2025 report (DAFM 2015) has set a target to increase the value of primary agricultural production by 65% by 2025 and has identified the expansion of the dairy sector as making a key contribution in achieving this target. The specific growth scenarios[12] for the expansion of the dairy sector are displayed in Table 7.1

**Table 7.1 Food Wise 2025 Scenarios**

| | Base Case 2025 | Base Case+ 2025 |
|---|---|---|
| Milk Production:<br>Percentage change relative to 2012-2014 average | 49.3% | 64.2% |
| Milk Production:<br>Estimates of actual volumes in millions of litres | 8,100 | 8,920 |

Laepple et al (2013) and Thorne et al (2015) used a farm simulation model based on Teagasc National Farm Survey data to project how the Food Harvest 2020 targets could be achieved and to estimate the associated investment requirements. The same approach is used here to simulate the growth scenarios set out in Table 7.1. The model is based on the assumption that the existing population of farms follow a phased expansion strategy whereby they first increase deliveries per cow, then increase cow numbers within existing resources and then begin to upgrade existing farm facilities to facilitate more cows. It is assumed that the existing population of farmers are profit maximisers and will continue to expand if the marginal revenue from the additional litre of production exceeds the marginal cost. The maximum expansion capacity of the existing population of farms is estimated as is the associated investment required to fully exploit this capacity. If this expansion falls short of the Food Wise aggregate production scenarios, it is then assumed that the remainder of the additional production is supplied by new entrants. The investment costs associated with a new entrant are taken from the Teagasc Greenfield project and are fully outlined in Thorne et al (2015).

Table 7.2 outlines the total number of farms and cows required to achieve the two Food Wise 2025 scenarios. The analysis is based on a "moderate outlook" for the sector as described in Thorne et al (2015). This outlook assumes an average milk price in the 2025 period of 32 cent

[12] See footnote 2

per litre. As is evident from Table 7.2, the existing population of farms supply the bulk of the additional milk in the Base Case where only 831 new entrants are required. Considerably more new entrants are required for the Base Case+ scenario where almost 2,000 new entrants are required to produce the almost 9 billion litres of milk.

**Table 7.2 Food Wise 2025 Scenarios: Production volumes, farms and cows required**

| | Base Case 2025 | Base Case+ 2025 |
|---|---|---|
| Milk Production:<br>Estimates of actual volumes in millions of litres | 8,100 | 8,920 |
| Number of Cows Required ('000) | 1,550 | 1,690 |
| Total Number of Farms | 16,477 | 17,559 |
| Of which are new entrants | 831 | 1,913 |

Table 7.3 outlines the investment required for the two scenarios. This comprises the investment made by existing farmers in upgrading their facilities as well the investment undertaken by new entrants. A collective investment of between €1.7 and €2.2 billion by the farm sector is required to achieve the two Food Wise scenarios. In both cases about one-third of this investment is in the acquisition of new cows. In the case of existing farms this is likely to be funded by profit foregone by retaining young animals that would normally be sold. It is estimated that between €257 and €413 million would need to be invested in buildings and infrastructure. This includes the upgrading of existing animal housing, the construction of new animal housing, improvements to yarding and the upgrading or instalment of roadways. An investment of over €800 million in milking parlours is required. This includes both the construction of the milking parlour itself but more significantly all of the milking equipment contained within. Finally, it is estimated that between €35 and €81 million would need to be invested in land improvements. This would include activities such as reseeding and the provisioning of water in fields to animals.

**Table 7.3 Food Wise 2025 Scenarios: Investment Requirements in millions**

| | Base Case 2025 | Base Case+ 2025 |
|---|---|---|
| | €million | €million |
| Acquisition of Cows | 561 | 744 |
| Buildings & Infrastructure | 257 | 413 |
| Milking Parlour | 878 | 986 |
| Land Improvements | 35 | 81 |
| Total | 1,731 | 2,224 |

### 7.3 RESULTS

*Wider economic impact of the projected investment needs of the dairy sector to reach 2025 Food Wise Scenarios*

The analysis presented here utilises the Bio-Economy Input-Output model developed by SEMRU, NUI Galway and Teagasc (O'Donoghue et al., forthcoming) and building upon previous work led by Prof Alan Matthews (Miller et al., 2014). This model has been developed to assess the output and employment multipliers of public policy initiatives such as the Agri-Food 2025 strategy and the Harvesting Our Ocean Wealth strategy.

The model disaggregates the national Input-Output Model of the CSO to incorporate primary, industry and service sectors across the Bio-Economy incorporating detailed Agri-Food, forestry and marine sectors. In Table 7.4, we report the output and employment multiplier associated with the dairy investment. Under the Base case, scenario a €1.7bn farm level investment, results in a total output increase of over €4bn, with just under €3bn of that in the domestic economy. For the Base Case + scenario, a €2.2bn investment leverages €5.3bn euro in output, with €3.8bn in domestic output growth.

We used average employment numbers using two approaches, firstly using total output and secondly using domestic output. The Base Case scenario delivers 31,466 jobs, while the Base Case+ scenario delivers 40,751 jobs. In both cases the employment impact is virtually the same, with the output total about 1% higher. The reason for the similarity is that although the domestic multiplier is lower, employment multiplier is higher as the denominator (output) is lower than in the total output. It should however be noted as in the case of Chapter 5 that the marginal multiplier is likely to be a good deal lower than this, which should be regarded as an upper bound.

**Table 7.4 Output and Employment Multiplier for Dairy Investment**

| | Base Case 2025 | Base Case+ 2025 |
|---|---|---|
| **Output** | €m | €m |
| Direct | 1,731.0 | 2,224.0 |
| Total Output | 4,128.1 | 5,308.1 |
| Domestic Output | 2,985.7 | 3,837.5 |
| **Employment** | Jobs | Jobs |
| Total | 31,466.8 | 40,751.9 |
| Domestic | 31,148 | 40,397 |

### 7.4 Summary and Conclusions

This chapter has shown that Irish dairy farmers in general have a sound financial structure. Debt to asset levels are quite low by international standards and solvency, liquidity and financial efficiency indicators all compare favourably with our main competitors in Europe.

Traditionally, dairy farmers have been the most active investors and this is a situation that is likely to continue in the current no quota environment. However, significant investment and credit will be required if the farming sector is to achieve the growth scenarios as laid down in the Food Wise 2025 report.

Sound financial planning on the part of farmers in conjunction with the banks will be critical to safeguarding farmers from financial stress. Given the current historically low interest rates in addition to the inevitability of output price volatility, it is prudent that all expansion plans are adequately stress tested.

# Chapter 8. THE ECONOMIC IMPACT OF FINFISH AQUACULTURE INVESTMENT

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## 8.1 INTRODUCTION

The rapidly rising demand for marine food products cannot be satisfied sustainably by wild fish stocks alone (Pauly et al. 2002). With the current world population of 7.3 billion expected to reach 8.5 billion by 2030 and 9.7 billion by 2050 (UN DESA), a substantial expansion in food production, including seafood, will be required to meet the needs of this expanded population. Coupled with this increase in population, is the rapid economic development that is taking place in Asia. It is expected that by 2020 over one half of the world's middle class will reside in the Asian Pacific region (World Bank, 2013). Given the higher rates of consumption of seafood in this area, the global demand for seafood is expected to increase dramatically (FAO, 2013). There is already evidence of the growth in consumption of seafood in China, where in 1995 per capita consumption was just 7kgs. By 2020 it is expected to reach 36kgs per capita (BIM, 2014). Also, according to the World Bank (2013), global aquaculture production has already expanded rapidly to meet the demands of consumers. They observe that, over the period 1981 to 2011, aquaculture production has increased at an average annual rate of more than 8 percent, from 5.2 million tons in 1981 to 62.7 million tons in 2011.

To meet the expected increase in global seafood demand, aquaculture is rapidly emerging as an alternative to commercial fishing (Edwards, 2009). Nearly half of the global fish demand and 20% of European consumption was met by the aquaculture industry in 2011 (EC, 2013) and this proportion is rising. However, while aquaculture alleviates pressure on wild fish stocks, it can have negative effect on its direct environment through demand for fish feed (Naylor et al. 2009), the intensive use of drugs and chemicals (Cabello, 2006); and the introduction of waste products to the environment (Talbot and Hole, 2007 and Pillay and Kutty, 2010). On a global scale, aquaculture has been shown to decrease pressure on wild fish stocks but the environmental impact can be substantial and cannot be ignored if fish production is to be optimized (Roderburg, 2007).

Currently, aquaculture in Ireland consists of approximately 850 licensed operations covering 2,000 sites, primarily consisting of shellfish production. The number of active enterprises engaged in marine aquaculture has remained stable with approximately 300 enterprises operating in Irish waters (SEMRU, 2015). In recent years, there has been a reported increase in salmon and gigas oyster production, while mussel production has decreased due to both seed supply and market demand reduction. Production in Ireland's aquaculture industry has oscillated in recent decades. Salmon production peaked in 2001 at 23,000 tonnes. However, these production levels could not be maintained due to an outbreak of Pancreas Disease and high feed conversion ratios, leading to sub-optimal stock performance (McLoughlin et al, 2003). Additionally, large quantities of salmon were dumped on the European market by Norway and Chile, resulting in a decline in market prices. This limited the profitability of the sector, resulting in a decline of Irish aquaculture production until it reached 12,000 tonnes in 2005 (BIM & Marine Institute, 2007). Finfish production levels are now approximately half of what they were in 2001.

According to figures from SEMRU's latest 'Irish Ocean Economy Report' (SEMRU, 2015) Ireland produced 36,200 tonnes of farmed product in total in 2012 and there were 279 operations engaged in the sector during that period, of which the majority were engaged in shellfish aquaculture, producing 22,700 tonnes, whilst other marine species account for 12,400 tonnes of production. The report also highlights that the turnover generated by marine aquaculture in 2012 was €130 million. Total GVA generated was €61 million. Turnover increased between 2010 and 2012 by 6%, with a 31% increase in GVA in the same period. Employment in the aquaculture sector was 956 FTEs in 2012, which shows an increase of just 0.4% with respect to 2010. A large proportion of those working in the sector (approximately 83%) are employed along the Western seaboard. According to SEMRU (2015) total investment in aquaculture during 2013 amounted to €1,382,539

In terms of national policy, BIM has recently published its Seafood Strategy for the period 2013 – 2017 (BIM, 2014). The strategy has the main objective of expanding and significantly developing the aquaculture sector in Ireland. The government's Food Harvest 2020 strategy set ambitious targets for the aquaculture sector with a target of a 78 per cent increase in aquaculture volume production by 2020.

One of the ways it has been proposed to achieve these growth targets is to establish high capacity offshore organic salmon farms off the west coast of Ireland. As part of this strategy, BIM is leading a project to develop three deep sea salmon farms. It is proposed that each farm will be capable of producing 15,000 tonnes of organic salmon annually, valued at €105 million. One such farm has been proposed for just inside one of the Aran Islands of the Galway coast. There are significant challenges to this idea and the massive capacity envisaged for such sites is far greater than that of any of the hypothetical offshore models that have been developed previously (primarily in Scotland and the United States). The development of such large scale farms could have significant regional and national impacts as well as a significant impact on the export market for Irish organic salmon.

Given the scale of the proposed farms and the lack of comparable sites with financial data available, potential economies and diseconomies of scale are unknown. There is an understandable lack of certainty in relation to eventual cost structures and thus no agreed basis on which to assume cost or labour structures different to those currently observed. Consequently, this chapter considers the macroeconomic and employment impacts of an increase in output of the aquaculture sector if the planned output increase from just one of these farms was achieved (15,000 tonnes) – whether this expansion occurs at just one farm site or across multiple sites along the west coast is not controlled for. Given the nature of the data and the unknown size of the possible negative impacts on other sectors in the economy (such as recreational angling and tourism) the analysis only examines the positive impact from the expansion in the aquaculture sector.

## 8.2 METHODOLOGY

*An Input-Output Approach*

Estimating the potential macroeconomic impact of a large increase in output from finfish aquaculture requires a comprehensive understanding of the sector's placement within the wider economy. Input-Output analysis is a widely used methodology within economics that measures the flows of products from each industrial sector, considered as a producer, to each of the sectors in the economy. As such, we make use of the Bio-Economy Input-Output model described in earlier chapters to estimate the impact on the wider economy from the expansion of the aquaculture industry by 15,000 tonnes of finfish per annum. For the purposes of modelling the direct and indirect impacts on output it is assumed that the intermediate consumption profile of the finfish sector matches the aquaculture sector as a whole.

Within the Bio-Economy Input-Output model, the aquaculture sector is separated from the Agriculture, Forestry and Fishing sectors using information collected from the Irish Ocean Economy Report (SEMRU, 2015). Information on total output and GVA for the sector is used to provide an estimate for total intermediate consumption. Additionally, in order to provide an accurate disaggregation, information on the sources of inputs and destination of output from the aquaculture sector is required. Due to the limited availability of detailed survey information on inputs in the Irish aquaculture industry, intermediate consumption shares for the aquaculture sector are apportioned on the basis of input shares calculated from fish farm case studies. Equivalent input shares reported in a prospective analysis of the aquaculture sector in the EU published by the Joint Research Centre (European Commission, 2008) were found to be comparable. Expenditure from the aquaculture sector on feed, juveniles, boats, engineering costs, veterinary costs, repairs and maintenance, fuel, diving and other inputs are assigned to their relevant source sectors in the Input-Output table from which a new aquaculture column is created. In addition, it is also assumed that the share of individual intermediate inputs imported from abroad follows the same distribution reported in the 2010 Input-Output tables (CSO, 2014). Import ratios for each product's intermediate consumption are calculated and applied to the estimated intermediate inputs for aquaculture with the balance aggregated and reported as required imports in the production process.

For the destination of output it is assumed that the share of inputs devoted to juveniles is sourced from within the aquaculture industry itself with the remaining output flowing to the seafood processing sector enabling the addition of a new aquaculture row. In addition to the impacts of expansion in the aquaculture industry, the impacts on the seafood processing sector are also investigated. The export profile for both sea fish and aquaculture recorded in the Ocean Economy Report (SEMRU, 2013) is approx. 43% with the remainder flowing to seafood processing and a nominal amount flowing to final demand. Given the scale of the simulated aquaculture expansions it has been assumed that 50% of new production will be exported with the remainder flowing to the seafood processing sector.

To estimate the employment effects of the proposed expansion, the appropriate employment multiplier is required. The employment multiplier is the ratio of direct plus indirect employment changes to the direct employment change. An employment multiplier for the aquaculture sector has been estimated and reported in Chapter 6 on the basis of the existing labour/output ratio reported in the Irish Ocean Economy Report (SEMRU, 2015) and labour/output ratios calculated from the disaggregated employment totals reported in the 2011 'Profile at Work Report' (CSO, 2012). However, there is a substantial difference between the existing labour output ratios for shellfish and finfish.

Given that recently mooted plans for large scale aquaculture expansion have centred on finfish, a direct employment coefficient of 2.26 jobs/€m output for the production of finfish has been applied in line with the ratio of employment to output observed for finfish aquaculture in Ireland. Employment coefficients for all other sectors have been maintained. Due to the lack of equivalent data for the modelled year it is assumed that the employment share profile for all other sectors for 2010 is as reported in the 2011 'Profile at Work Report'.

This chapter considers the macroeconomic impact of a €105m increase in the output of the finfish sector and the knock on effects for the seafood processing sector as they are currently structured, i.e. there is currently no established basis on which to estimate cost or labour structures which are different to those currently observed in the sector as a whole. Additionally, due to limited data availability, disaggregated information on the components of GVA and nominal figures for final demand (i.e. final consumption of households, governments plus transfers, non-profit organisations, etc.) for the aquaculture sector are not included. Consequently, the output multiplier calculated for the industry reports the direct and indirect effects only of a marginal increase in output. It does not include any induced effects as a result of changes in household incomes.

## 8.3 RESULTS

*Finfish Aquaculture*

Table 8.1 reports results for the estimation of the economic impacts of an increase in utilisable finfish aquaculture output of approximately 15,000 tonnes per annum. Based on a unit price of €7.00 per kilo, the increase in exogenous demand required to absorb the increased levels of production is estimated at €105 million per annum. We estimate an output multiplier of 1.41 for the aquaculture sector based on the newly disaggregated Input-Output table. Overall, this results in an estimated additional indirect effect of €43 million per annum in the wider economy, resulting in a total economic impact of €148 million per annum.

**Table 8.1 Economic Impacts of an increase of €105 in Output from the Aquaculture sector**

| Net Tonnage | Price/Kg | Increase in Aquaculture Demand |
|---|---|---|
| 15000 | €7.00 | €105m |
| Aquaculture Output Multiplier | | 1.41 |
| Direct Effect | | €105m |
| Indirect Effect | | €43m |
| Total Economic Impact (€) | | €148m |

Table 8.2 reports the estimated employment impacts. Based on the adjusted labour/output ratios for finfish, an increase of €105m in finfish aquaculture is estimated to result in an additional 237 jobs at a rate of 2.26 jobs/€m. Based on the adjusted employment multiplier of 2.06 for the finfish sector, we project that the expansion will also results in an estimated 252 indirect jobs in the wider economy, resulting in a total employment impact of 489.

**Table 8.2 Employment Impacts of an increase of €105 in Output from Finfish Aquaculture**

| | |
|---|---|
| Increase in Finfish Aquaculture Demand | €105m |
| Direct Jobs @ 2.26/€m | 237 |
| Aquaculture Employment Multiplier | 2.06 |
| Indirect Jobs @ 5.90/€m | 252 |
| Total Additional Employment | 489 |

Table 8.3 Reports the sectoral disaggregation of indirect employment. The most significant impact will be in the supporting services sectors. A significant amount of jobs (160) created indirectly will occur in the areas of licencing, insurance, rental and leasing of equipment, veterinary services and repairs and maintenance. The sourcing/provision of feed from the food processing sector and the sourcing of immature/juvenile product from within the aquaculture sector itself will provide an additional 52 jobs, with the remaining 40 jobs coming primarily from marine engineering and construction.

**Table 8.3 Sources of Indirect Employment from a €105 increase in Finfish Aquaculture**

| | |
|---|---|
| Primary | 52 |
| Manufacturing | 40 |
| Services | 160 |
| Total Indirect Jobs @ 5.90/€m | 252 |

*Seafood Processing*

In addition to the direct and indirect benefits due to the expansion of finfish production, further benefits from an expansion in the seafood processing sector are considered. Based on the existing input share of raw product[13] to intermediate consumption it is estimated from The Bio-Economy Input-Output model that an expansion of €185m will be required in the seafood processing sector if 50% (€52.5m) of the additional aquaculture output is processed domestically. Table 8.4 reports the direct and indirect impacts of this expansion. While, the seafood processing multiplier of 1.65 results in an indirect impact of €120m, this figure must be adjusted to avoid double counting the direct and indirect impacts of the original finfish aquaculture expansion. As 50% of the expansion is assumed to flow to seafood processing, €74m of the €148m total economic impact from the original finfish aquaculture expansion is removed giving a net indirect impact of €46m. This results in a total net economic impact of €231m as a result of a €185m increase in the seafood processing sector.

**Table 8.4 Net Economic Impact of a €185m increase in Seafood Processing Sector**

| | |
|---|---|
| Seafood Processing Output Multiplier | 1.65 |
| Direct Effect | €185m |
| Net Indirect Effect | €46m |
| Total Net Economic Impact (€) | €231m |

Table 8.5 reports the estimated net employment impacts of a €185m increase in the Seafood processing sector. An increase of €185m in seafood processing is estimated to result in an additional 753 jobs at a rate of 4.07 jobs/€m. The indirect employment figure of 361[14] has been adjusted to avoid double counting the direct and indirect employment impacts of the original finfish aquaculture expansion.

**Table 8.5 Net Employment Impacts of a €185 increase in Seafood Processing Sector**

| | |
|---|---|
| Increase in Seafood Processing Output | €185m |
| Direct Jobs @ 4.07/€m | 753 |
| Aquaculture Employment Multiplier | 2.05 |
| Indirect Jobs @ 1.56/€m | 361 |

[13] In order to simulate the required expansion of the seafood processing sector within the existing BIO model it was assumed that the ratio of raw material to other intermediate inputs required for seafood processing was constant with no distinction as to whether the raw material was sourced from sea fishing or aquaculture. This enabled the estimation of the required expansion of the seafood processing sector in order to absorb an increase in raw seafood material of €52.5m.

[14] Due the structure of the BIO model there is a discrepancy between the number of indirect jobs attributed to sea fishing and aquaculture as a result of the seafood processing expansion and the total jobs attributed to the original finfish aquaculture expansion. The net indirect jobs figure of 361 is the total indirect employment effect of 790 attributed to the seafood processing minus the indirect proportion attributed to sea fishing and aquaculture. See footnote 13 above.

| | |
|---|---|
| Total Additional Employment | 1,114 |

Table 8.6 describes the total economic and employment impacts as a result of a €105m increase in finfish aquaculture output and a consequent increase in seafood processing output of €185m. In terms of output, it is estimated that the total economic impact of €379m will be observed consisting of €148m from finfish aquaculture and €231m from seafood processing. This is comprised of a direct effect of €290m and an indirect impact of €89m

In terms of employment, it is estimated that the total employment impact of 1,603 additional jobs will be observed consisting of 489 from finfish aquaculture and 1,114 from seafood processing. This is comprised of a direct effect of 990 jobs and an indirect employment impact of 613 jobs.

**Table 8.6 Total Economic and Employment Impact of a €105m Finfish Aquaculture Expansion**

| | |
|---|---|
| Output | |
| Finfish Aquaculture – Direct and Indirect Output | €148m |
| Seafood Processing – Net Economic Impact | €231m |
| **Total Economic Impact** | **€379m** |
| Employment | |
| Finfish Aquaculture – Direct and Indirect Employment | 489 |
| Seafood Processing – Net Employment Impact | 1,114 |
| **Total Employment Impact** | **1,603** |

As in the case of the marine sector generally and similar to sectors such as Agriculture, Forestry, Construction and Food Processing, the aquaculture sector is deeply embedded in the Irish economy and relies primarily on inputs from domestic resources. This means that the expansion of the aquaculture sector, in line with Ireland's Ocean Wealth Strategy, has the potential to have substantial positive knock-on effects in terms of employment and value added in the wider economy. In a similar pattern to the indirect employment effects, the indirect impact on the output of other sectors is to be seen right across the economy but to a larger extent on the supporting services sectors. Motor fuel and vehicle trade and repair, public administration , insurance, reinsurance and pension funding, agriculture, forestry and fishing, wholesale trade, architectural and engineering services, legal and accounting services; management consultancy, financial intermediation services, computer consultancy and data processing are some of the main sectors that would benefit from expansion in Irish aquaculture.

## 8.4 Discussion and Conclusions

Within the context of the Food Harvest 2020 strategy, aquaculture in Ireland has the potential to contribute significantly to Irish exports and to create additional employment in the domestic market. This is particularly significant for a number of regions which traditionally have struggled to provide sustainable, long-term permanent employment for local residents. This chapter has evaluated the potential macroeconomic and employment impacts of an increase in aquaculture output equivalent to that proposed for large-scale organic salmon farms along the West coast of Ireland. It is projected that such an expansion in the sector would support the direct and indirect employment of over 1,600 people, with an overall economic impact of an increase of approx. €379 million per annum in the wider Irish economy assuming a substantial proportion of the resultant raw seafood material will be processed domestically.

However, a number of caveats need to be restated. This chapter only considers the macroeconomic impact of the proposed development and does not capture any non-market costs or benefits be they environmental, social or cultural which may accrue as a result of such an expansion in aquaculture production. Also, the potential economies and diseconomies of scale which may be associated with large scale fish farms of the west coast of Ireland are not considered. The Bio-Economy Input Output model used considers only the resulting macroeconomic impact of the additional finfish aquaculture and seafood processing output as the sectors are currently structured, rather than on any hypothetical future sectoral configuration. In addition, the employment estimates are based on an increase of capacity of 15,000 tonnes per annum but do not consider any time-lag effects which may occur in the interim as the installation approaches full capacity.

Nevertheless, the results of the model do show that the expansion of the sector could have significant impacts on the wider economy. While the Input Output model is a national level model it would be expected, given the predominate location of aquaculture and supporting services outside of major population centres, that the impacts from the expansion will be felt in rural areas where employment opportunities may be limited. The possibility of expansion in aquaculture as a means to improve the prospects of rural communities was highlighted in the recent report by the Commission of Economic Development of Rural Areas (CEDRA, 2014). The expansion considered here is also only a minimum of what could be possible. Ireland is a small player in the global market and expansion in the industry here is unlikely to dampen market prices which have been increasing steadily in recent years (Bloomberg, 2014). With the forecasted increases in global population, the increased affluence of seafood consuming countries in the Far East and the opening up of the Chinese market in 2014 to organic salmon from Ireland (Inshore Ireland, 2013) the prospects for expansion of aquaculture beyond even the level analysed here is possible and as demonstrated in this chapter the knock on effects on the wider economy could be substantial.

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## APPENDIX DISTRIBUTION OF INPUTS IN THE NFS BY SUB-SECTOR

| | Conc. Feed (Own) | Conc. OB | Pasture | Winter Forage (Own) | Silage (Own) | Hay (Own) | Winter Forage (OB) | Silage (OB) | Hay (OB) | Winter Forage (Purch) |
|---|---|---|---|---|---|---|---|---|---|---|
| Concentrate Own | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Concentrate Opening | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pasture | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Winter Forage Own | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Silage own | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hay Own | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Winter Forage Op | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Silage Op | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hay Op | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Winter Forage Pur | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other Cash Crop | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Potato Fruit &Veg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Set-aside | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sugar Beet | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dairy | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Roots | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Vet and Medical | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AI | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Transport | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Misc | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Labour | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total dairy Deductions | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Super Levy Charge | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Super Levy Refund | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Milk Quota Lease | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fert used value | 0.14 | 0.00 | 0.43 | 0.03 | 0.28 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |
| Allocated to crop | 0.03 | 0.00 | 0.00 | 0.01 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Home grown seed value | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Crop protection | 0.52 | 0.00 | 0.10 | 0.06 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Purchased seed | 0.31 | 0.00 | 0.17 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Transport gross cost | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Transport subsidy | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Machinery hire | 0.10 | 0.00 | 0.12 | 0.05 | 0.60 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |
| Miscellaneous | 0.01 | 0.00 | 0.00 | 0.02 | 0.16 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Land rented in | 0.09 | 0.01 | 0.04 | 0.02 | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Car, electricity, telephone | 0.04 | 0.00 | 0.06 | 0.01 | 0.10 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Hired labour casual excl | 0.07 | 0.01 | 0.03 | 0.01 | 0.04 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Interest pay incl hp interest | 0.05 | 0.01 | 0.04 | 0.01 | 0.07 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Machine operating expenses | 0.07 | 0.01 | 0.05 | 0.01 | 0.08 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Deprec. of machinery | 0.08 | 0.01 | 0.05 | 0.01 | 0.08 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Deprec. of buildings | 0.03 | 0.01 | 0.06 | 0.00 | 0.09 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Buildings repairs upkeep | 0.04 | 0.01 | 0.05 | 0.01 | 0.08 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Land general upkeep | 0.05 | 0.01 | 0.06 | 0.01 | 0.10 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Deprec. of land imps | 0.04 | 0.01 | 0.06 | 0.01 | 0.10 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Misc overhead costs | 0.06 | 0.01 | 0.05 | 0.01 | 0.09 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Concentrate Purchase | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total Overhead Costs | 0.06 | 0.01 | 0.05 | 0.01 | 0.08 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Direct Costs | 0.05 | 0.00 | 0.08 | 0.01 | 0.12 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Output | 0.07 | 0.00 | 0.05 | 0.01 | 0.07 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Agri | 0.02 | 0.00 | 0.03 | 0.01 | 0.15 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |

| | Other Cash Crop | Potato Fruit & Veg | Set-aside | Sugar Beet | Dairy | Roots | Milk Quota Lease | Home grow seed value | Machi nery hire | Cattle | Sheep | Horses | Pigs | Poultry | Deer and Goats | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conc. Own | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.81 | 0.03 | 0.00 | 0.04 | 0.00 | 0.01 | 1.00 |
| Conc. Opening | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.81 | 0.03 | 0.00 | 0.04 | 0.00 | 0.01 | 1.00 |
| Pasture | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 | 0.05 | 0.06 | 0.00 | 0.00 | 0.01 | 1.00 |
| Winter Forage Own | 0.00 | 0.00 | 0.00 | 0.00 | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 1.00 |
| Silage Own | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.69 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Hay Own | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.80 | 0.10 | 0.00 | 0.00 | 0.00 | 0.02 | 1.00 |
| Winter Forage Op | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Silage Op | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.73 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 1.00 |
| Hay Op | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.49 | 0.07 | 0.40 | 0.00 | 0.00 | 0.02 | 1.00 |
| Winter Forage Pur | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.61 | 0.02 | 0.07 | 0.00 | 0.00 | 0.01 | 1.00 |
| Other Cash Crop | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Potato Fruit & Veg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Set-aside | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sugar Beet | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dairy | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Roots | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.80 | 0.00 | 0.00 | 0.00 | 0.20 | 1.00 |
| Vet and Medical | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.47 | 0.06 | 0.09 | 0.07 | 0.00 | 0.01 | 1.00 |
| AI | 0.00 | 0.00 | 0.00 | 0.00 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 | 0.41 | 0.00 | 0.00 | 0.00 | 1.00 |
| Transport | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.01 | 0.00 | 0.13 | 0.00 | 0.00 | 1.00 |
| Misc | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Labour | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.00 | 0.72 | 0.00 | 0.01 | 1.00 |
| Tot. dairy deductions | 0.00 | 0.00 | 0.00 | 0.00 | 0.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Super Levy Charge | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Super Levy Refund | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Milk Quota Lease | 0.00 | 0.00 | 0.00 | 0.01 | 0.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Fert used value | 0.03 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Allocated to crop | 0.00 | 0.86 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Home grown seed value | 0.00 | 0.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Crop protection | 0.08 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Purchased seed | 0.14 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Transport gross cost | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Transport subsidy | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Machinery hire | 0.05 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Miscellaneous | 0.00 | 0.08 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.03 | 0.13 | 0.08 | 0.00 | 0.01 | 1.00 |
| Land rented in | 0.04 | 0.18 | 0.00 | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.03 | 0.01 | 0.05 | 0.05 | 0.00 | 1.00 |
| Car, electricity, telephone | 0.01 | 0.03 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 0.05 | 0.02 | 0.04 | 0.02 | 0.00 | 1.00 |
| Hired labour casual excl | 0.02 | 0.24 | 0.00 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.02 | 0.04 | 0.05 | 0.00 | 0.00 | 1.00 |
| Interest pay incl. hp interest | 0.01 | 0.13 | 0.00 | 0.00 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | 0.02 | 0.04 | 0.05 | 0.02 | 0.00 | 1.00 |
| Machine Operating expenses | 0.01 | 0.08 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.04 | 0.03 | 0.03 | 0.09 | 0.00 | 1.00 |
| Deprec. of machinery | 0.01 | 0.11 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 | 0.04 | 0.03 | 0.01 | 0.04 | 0.00 | 1.00 |
| Deprec. of buildings | 0.01 | 0.03 | 0.00 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.04 | 0.02 | 0.03 | 0.04 | 0.00 | 1.00 |
| Buildings repairs upkeep | 0.01 | 0.04 | 0.00 | 0.00 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.05 | 0.02 | 0.03 | 0.11 | 0.00 | 1.00 |
| Land general upkeep | 0.01 | 0.03 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 0.06 | 0.02 | 0.01 | 0.04 | 0.00 | 1.00 |
| Depreciation of land imps | 0.01 | 0.02 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 | 0.04 | 0.03 | 0.01 | 0.10 | 0.00 | 1.00 |
| Misc overhead costs | 0.01 | 0.05 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 | 0.05 | 0.02 | 0.03 | 0.06 | 0.00 | 1.00 |
| Concentrate Purchase | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.38 | 0.04 | 0.00 | 0.25 | 0.08 | 0.01 | 1.00 |
| Total Overhead Costs | 0.01 | 0.09 | 0.00 | 0.00 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 | 0.04 | 0.03 | 0.03 | 0.05 | 0.00 | 1.00 |
| Direct Costs | 0.02 | 0.04 | 0.00 | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.02 | 0.03 | 0.09 | 0.02 | 0.01 | 1.00 |
| Output | 0.02 | 0.06 | 0.00 | 0.00 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.28 | 0.03 | 0.03 | 0.06 | 0.02 | 0.01 | 1.00 |
| Agri | 0.01 | 0.03 | 0.00 | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.49 | 0.02 | 0.03 | 0.00 | 0.00 | 0.01 | 1.00 |

## APPENDIX: INPUT-OUTPUT TABLES

### 2010 SYMMETRIC BIO-ECONOMY INPUT-OUTPUT TABLE OF DOMESTIC PRODUCT FLOWS AT BASIC PRICES €M

### 2010 BIO-ECONOMY LEONTIEF INVERSE MATRIX OF DOMESTIC PRODUCT FLOWS

The Bio-Economy Input-Output Table and Leontief Inverse Matrix are available on the Teagasc website (www.teagasc.ie)

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