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Coláiste na hOllscoile Corcaigh

2018

The Economic and Societal Importance of the Irish Suckler Beef Sector

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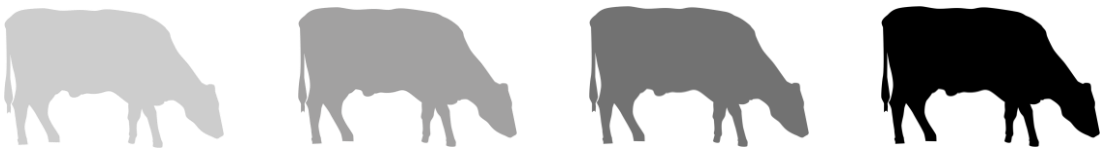
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Abbreviations

AHC	American Humane Association
AWA	Animal Welfare Approved
AWI	Animal Welfare Index
CHP	Certified Humane Programme
CSO	Central Statistics Office
CW	Carcass weight
CAP	Common Agricultural Policy
DAFM	Department of Agriculture, Food and the Marine
ENRD	European Network for Rural Development
FDA	Food and Drug Administration
GAP	Global Animal Partnership
GDP	Gross domestic product
GHG	Greenhouse gas
GNP	Gross national product
GVA	Gross value added
ICBF	Irish Cattle Breeding Federation
n.a.	Not available
NFS	National Farm Survey



Executive Summary

The beef sector in Ireland is very significant accounting for over one-third of all agricultural output and over 20 percent of total Irish food and drink exports. The agri-food sector in general provides direct and indirect employment to over 300,000 people with over 13,000 employed in the meat processing sector alone. The value of beef exports is growing and exceeded €2.6 billion in 2017. Domestic consumption of Irish beef accounted for a further €230 million last year. In all, the value of the Irish beef sector is estimated to be almost €2.9 billion.

The large and productive beef sector is supported by a suckler cow herd of approximately 1 million cows according to CSO data, although recent reports based on the DAFM Animal Movement Identification System put the figure closer to 900,000. The suckler cow herd is distributed throughout the country but particularly dominating in the West. The important regional presence of the suckler cow sector is reflected in the fact that suckler cows account for over 80 percent of cows in the West, with the figure in excess of 90 percent in some counties.

Cattle farmers make a considerable contribution to the Irish local economy both through the inputs they purchase and the outputs produced. There are 77,738 specialist cattle farms in Ireland. It is estimated that cattle farmers spend over €1.5 billion annually on agri-inputs, most of which is spent in the local rural economy.

The economic impact of agriculture and beef in particular is considerable and exceeds that of many other sectors in the Irish economy, meaning that an increase in output in the beef sector generates relatively more economic activity than a comparable increase in other industrial sectors. Indeed, the multiplier effect for the beef sector is greater than that of the agriculture sector in general, that is to say that a €1million increase in beef sector output would generate a further €2.11 million in the wider economy and support an additional 16 jobs. The comparative figure for the agriculture sector more generally is €1.44 million.

Direct payments made to farmers also make a substantial contribution to the wider rural economy as farmers use these payments to purchase inputs and to generate output that leads to further economic activity. Previous research has estimated that every €1 of direct payments to cattle farmers supports €4.28 of output in the wider economy.

In addition to the economic impact, suckler farmers contribute to wider societal sustainability, particularly as they are often located in marginal or economically disadvantaged areas, where their presence is vital to the social fabric and cultural capital. They produce public goods such as protection of the environment and biodiversity and the preservation of the landscape and unique features such as stonewalls and hedgerows all of which positively contribute to the

image of rural Ireland and rural tourism. Previous research has shown that extensive grass based farm systems, such as suckler cow farming, deliver higher levels of public goods.

For a small island on the edge of Europe, Ireland punches above its weight when it comes to beef exports. Ireland is the largest exporter of beef in the EU and the sixth largest exporter of beef in the world. The national suckler herd is of fundamental importance to Ireland's reputation as a major exporter of high quality prime beef. Cattle from the suckler herd generally have a superior grading profile and heavier weight for age resulting in higher saleable meat yield and higher value cuts.

The prevalence of Irish-owned companies in the beef sector and the relatively low reliance of beef farming and meat processing on imported inputs means that beef exports make a major contribution to net foreign earnings in the Irish economy. It is estimated that every €100 of exports from the biosector, which includes beef, generates €48 in net foreign earnings, while the non-biosector contributes €19.

Consumers worldwide are becoming increasingly concerned about the sustainability of food production. This provides a unique opportunity for Ireland as we produce some of the world's most sustainable beef. The carbon footprint of beef production in Ireland is well below the European average, it is the fifth lowest in Europe and is almost one-quarter of the Brazilian footprint. The Beef Data and Genomics Programme (BDGP) is delivering further carbon efficiencies with the ICBF estimating that by 2030 the genetic gain achieved through the programme will reduce greenhouse gas emissions by 14 percent per kilogram of beef produced.

There are many positives around the sustainable system of Irish beef production. The UN placed Ireland as the most water efficient producer of food globally with a 0.2 percent stress rating. Other international studies have shown that Ireland is the most nitrogen efficient producer of livestock products in Europe. Animal welfare in Ireland is extremely high by global standards, growth promoters and hormone treatments are forbidden and our clean, green image is a major marketing strength internationally. Furthermore, grass-fed beef has been proved to be healthier, lower in fat with a content of two to six times more Omega-3 fatty acids and as such demand for grass-fed beef is growing especially in affluent markets.

The economic outlook is for continued growth in the global demand for beef with the OECD/FAO projecting that global consumption of beef will grow by 9 percent by 2026. Ireland is well positioned to exploit this opportunity given our strong sustainability credentials and export focus. The recent opening of the Chinese and American markets for Irish beef is also a positive development especially in light of the potential threats posed by Brexit.

Notwithstanding the economic importance of the beef sector to the wider Irish economy and its continued success on international export markets, the beef industry is underpinned by a farm sector facing considerable economic difficulties. The income situation on cattle farms in Ireland remains challenging with the Teagasc National Farm Survey showing an average farm

income of just €12,529 on cattle rearing farms in 2017. On average, costs of production exceed market prices, and the reliance on direct payments is critical. Without a substantial increase in beef prices and/or improvements in efficiency levels the vast majority of cattle farmers will continue to rely on direct payments.

Furthermore, a number of threats loom on the horizon for the future of the Irish beef sector. Brexit and other international trade agreements such as Mercosur, threaten future trade patterns and ultimately farm-level prices. The impending reform of the Common Agricultural Policy may also impact on the value of direct payments to farmers. The impact of climate change policy on the ability of the sector to exploit future market opportunities is a further threat as Ireland is committed to a number of international agreements to reduce greenhouse gas emissions. In the context of sustainable food production however, international carbon leakage is a major concern. Carbon leakage occurs if Ireland reduces the production of beef to meet international policy commitments, but less carbon efficient countries increase beef production to satisfy growing international demand.

The very difficult income situation on Irish suckler farms is unsustainable and is already resulting in individual farmers reducing animal numbers leading to a loss in beef output, export values and employment. It is estimated that a 10 percent contraction in the suckler cow herd would lead to a loss in beef output of €145 million and a loss of total output in the economy of €305 million. A contraction in the Irish suckler cow herd may also lead to land abandonment in marginal areas, causing a loss of natural landscape features, biodiversity and a contracting rural community.

The Irish suckler cow sector is at a critical juncture. A number of factors threaten its future development and sustainability. Without positive action it is most likely that these factors will lead to a contracting national suckler cow herd. This will have implications for the large farming community engaged in suckler farming, the vibrancy of rural areas, the agri-input sector, employment in the beef processing sector and the value of exports from Ireland. These negative implications will be most harshly felt in the West of Ireland and particularly in local economies and communities where there may be limited alternative economic opportunities.

Chapter1: Introduction and Overview

This report provides an assessment of the current status of the Irish suckler beef sector and its importance in terms of economic and non-economic outputs and impacts. Commissioned by the Irish Farmers Association and conducted by University College Cork, the report aims to offer a basis for informed decision making and policy design that will influence the direction of the Irish beef sector in the coming years.

THE KEY OBJECTIVES OF THIS REPORT ARE TO:

- Assess the importance of the suckler cow herd in the context of Irish agriculture, the Irish beef sector and the Irish economy;
- Examine the economic and social impact of the suckler cow herd, especially in terms of people and employment; and
- Explore environmental and policy issues related to the suckler cow herd.

Throughout this report references are made to the beef sector, farm level sector, cattle farms, suckler herd, processing sector and agri-food sector. The following section provides some clarification to the frequently used terms and concepts in this report.

The primary agricultural sector in Ireland is comprised of 139,860 farms according to the Central Statistics Office (CSO). It is estimated that over 100,000 of these farms stock beef animals but just 77,738 are specialist beef cattle farms. The value of beef output generated by the primary agricultural sector is approximately €2.4 billion, this includes beef meat arising from dairy and beef breed animals. In this report non-dairy breed cows are referred to as suckler cows and the term suckler beef refers to the meat produced by non-dairy breed cows and their progeny. The Teagasc NFS is the official source of farm income data but represents just 84,599 farms, with the smallest farms excluded. The Teagasc National Farm Survey (NFS) distinguish between two types of specialist cattle farms; 'cattle-rearing' which includes farms stocking suckler cows and producing beef breed animals and 'cattle other' which includes farms fattening and finishing both beef and dairy breed animals. The Teagasc NFS represents 19,952 cattle-rearing farms and 27,025 cattle other farms. The beef sector, as referred to in this report, includes both the primary agricultural sector and the beef-meat processing sector.

Chapter 2: The Current State of the Beef Sector in Ireland

2.1 Introduction

The agri-food sector is one of Ireland's most important indigenous sectors, accounting for over 10 percent of national exports with an export value of €12.6 billion, while at the same time providing direct and indirect employment to over 300,000 people. Beef is one of the major subsectors accounting for over a third of total primary agricultural output in 2017. With a total farm–level output value of almost €2.5 billion, the beef sector includes the progeny of both beef breed suckler cows and dairy cows. The value of beef-meat exports is growing and exceeded €2.6 billion in 2017 with domestic consumption of Irish beef accounting for a further €230 million. In all, the value of the Irish beef sector is estimated to be almost €2.9 billion. This chapter assesses the current state of the Irish beef sector with an emphasis on the size, location and importance of the suckler herd.

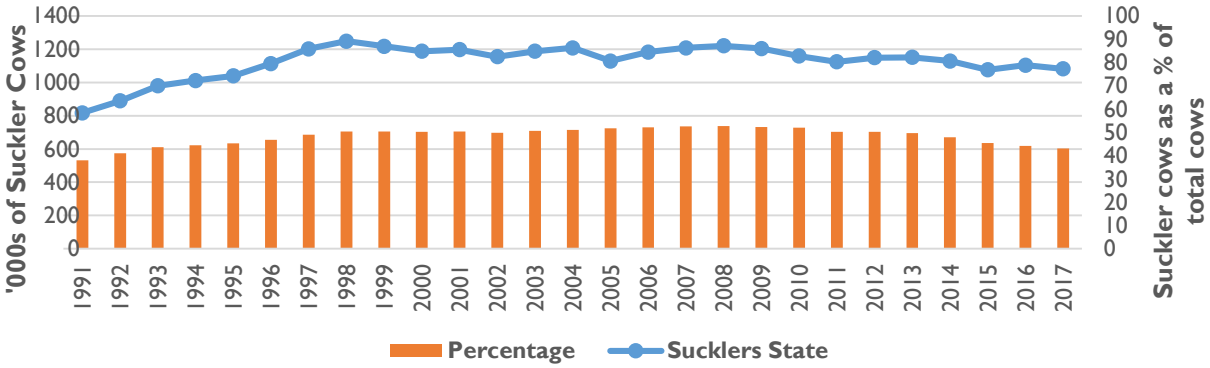
2.2 Prevalence of Suckler Cow Farming in Ireland

This section of the report considers the number of suckler cows in Ireland, their regional location and the importance of cattle farming to certain regions. The Central Statistics Office (CSO) publish the national statistics on cow numbers. The national herd is comprised of dairy cows and what the CSO refer to as "other cows". The dataset does not specifically identify suckler cows as such, but "other cows" can be considered to be comprised of mostly suckler cows, although it is possible that there is a small number of non-sucklers in this group. Hence forth in this report, the CSO series "other cows" will be referred to as suckler cows.

Figure 1 shows the number of suckler cows in Ireland from 1991 to 2017 as recorded in June of each year. Throughout the 1990s, during the Mac Sharry reforms of the Common Agricultural Policy when coupled payments were introduced, the number of suckler cows increased. Suckler cow numbers peaked in 1998 at 1.248 million cows. The introduction of decoupling in 2004 led to an initial stagnation in suckler cow numbers, with numbers declining more considerably since 2008. The total reduction in the number of suckler cows from 2008 to 2017 was 12 percent or a loss of 139,000 cows.[1]

[1] While the CSO produce the official statistics on cow numbers in Ireland, the Department of Agriculture, Food and Marine also publish data from their Animal Identification Movement System (AIMS) each year. In AIMS suckler cows are defined as "beef/beef cross female aged more than or equal to 18 months on December 31 of every year between 2010 and 2017 and registered as the dam of a calf born in the profile year". According to the AIMS database there were 870,000 suckler cows in Ireland in December of 2017.

Figure 1: Number of Suckler Cows and Percentage of Total Cows in the State 1991 to 2017



Source: Central Statistics Office of Ireland - CSO (2018a and 2018b).

The bars in the chart show suckler cows as a percentage of all cows in the country. Throughout the 1990s as suckler cow numbers grew, dairy cow numbers declined due to the milk quota constraint, and the national importance of suckler cows increased from comprising 38 percent of the national herd in 1991 to just over 50 percent in the early 2000s. In anticipation of the removal of milk quota, dairy cow numbers began to grow from 2010 onwards, and have increased by one-third in the last seven years. As a result, the proportion of suckler cows in the national herd has declined.

Table 1 presents the regional distribution of suckler cows in Ireland in 2010 and 2016 and the relative share of suckler cows in the total cow herd. Looking first at 2016, the regional specialisation in dairy versus beef is evident. In the West, 81 percent of all cows are classified as suckler, compared to just 22 percent in the South-West. Sucklers dominate in the Border and West, comprising 84 percent of all cows in Mayo and 93 percent of all cows in Roscommon and Leitrim. Furthermore, this regional concentration has become more pronounced over time, with the share of non-dairy cows declining fastest in the two South regions while remaining largely unchanged in the Border and West regions.

Table 1: Regional Distribution and Relative Share of Suckler Cows in Total Cow Herd 2010 and 2016

	2010		2016	
Region	Suckler Cows '000s	Suckler as % of Total	Suckler Cows '000s	Suckler as % of Total
Border	206	68	195	62
West	251	85	250	81
Midland	147	67	141	57
Mid-West	161	49	149	42
South-East	162	40	145	30
South-West	143	28	131	22
Dublin & Mid East	93	55	89	48
State	**1162**	**52**	**1103.7**	**44**

Source: CSO (2018b).

Table 2 presents the total number of farms, and those specialised in beef production, in Ireland and by region as recorded by the 2010 Census of Agriculture. Specialist beef farms include both farms that stock suckler cows and those that fatten suckler cow and dairy cow progeny.

Table 2: Regional Distribution of Farms, 2010

Region	All Farms	Specialist Beef Farms	Percentage of Specialist Beef Farms
Border	28,831	16,411	57
West	32,216	20,660	64
Midland	12,834	8,724	68
Mid-West	16,346	10,781	66
South-East	16,660	6,789	41
South-West	22,634	9,920	44
Dublin & Mid East	10,339	4,444	43
State	**139,860**	**77,738**	**55**

Source: CSO (2012a).

In summary, the number of suckler cows in Ireland has been in decline over the last decade, down 12 percent from 2008 to 2017. Recently, with the dairy herd expanding, the share of suckler cows has declined more rapidly, making up 44 percent of all cows in 2016 compared to 52 percent in 2010. Furthermore, the regional concentration has become more pronounced over time: in the West 81 percent of all cows are sucklers compared to just 22 percent in the South-West. In the counties of Galway, Mayo, Sligo, Roscommon and Leitrim, suckler farming is the predominant system, with suckler cows comprising over 80 and in some cases 90 percent of the cows in these counties.

2.3 Beef and Dairy Cow Breeds

The Irish beef sector is comprised of suckler cows and their progeny, and dairy cows and their progeny. Across Europe, more than two thirds of the cattle raised for beef originate from dairy, as opposed to suckler herds. However, according to Burke (2016), the national suckler herd is of fundamental importance to Ireland's reputation as an exporter of high-quality prime beef and live cattle as cattle bred from the suckler herd tend to be significantly more valuable than dairy-bred animals due to their superior grading profile.

Calves of beef and dairy breed cows differ in their average weight and value, with the average weight of beef calves (both male and female) exceeding that of dairy. The average weight of a beef cow is 356 kg and of a dairy cow 298 kg. Similarly, the average weight of a beef bull is 494 kg and of a dairy bull 379 kg. Data extracted from Bord Bia (2018) shows the average price of a male beef calf in Ireland in 2018 was €219.7 (excluding VAT) and that of a dairy calf was €136. Internationally beef breed calves also tend to command higher prices than dairy. Table 3 presents a comparison of average prices for beef and dairy calves in 2018 for Ireland, Spain and France. In all three countries the price for beef calves was considerably higher than that for dairy calves.

Table 3: Comparison of Average Beef and Dairy Calf Prices, Selected Countries in 2018

Country	Beef Calf	Dairy Beef Calf
Ireland	219.7	136.0
Spain	196.8 (continental)	111.6
France	240.9 (continental)	147.1

Source: Bord Bia (2018a).

Carcase classification is conducted on the basis of conformation (the shape and development of the carcase) and fat denoted by the letters E, U, R, O, P with E being the best and P the poorest. Carcases produced from the suckler herd result in superior carcase classification in

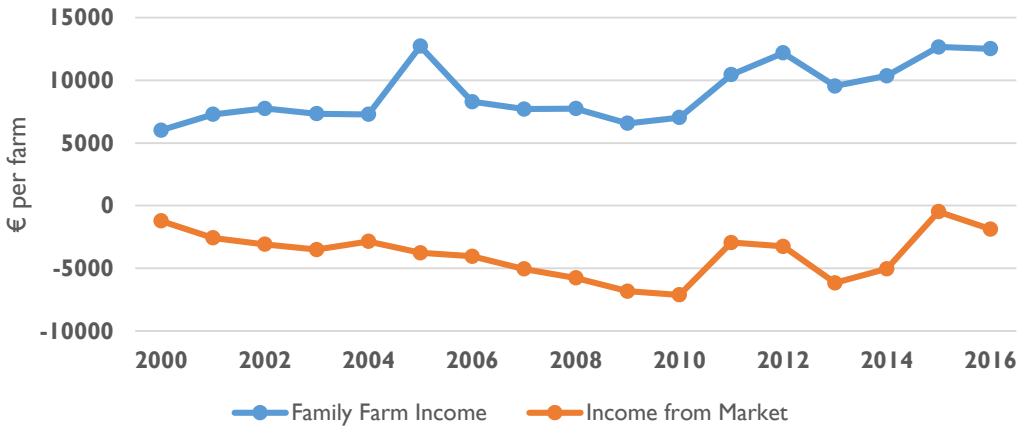
terms of conformation, and the resulting yield of saleable meat generates higher-value cuts (Burke, 2016). Suckler-origin cattle are typically sold at U or R grade in comparison to dairy origin cattle which typically sell at O and P grades. For a steer at an average fat class of 3, the price per kg varied from 354 cent per kg for P grade to 423 cent per kg for the U grade. This represents a 20 percent price premium for the suckler product.

Due to the expansion of the dairy sector the number of beef animals coming from the dairy herd is expected to increase and it is predicted that by 2025 dairy cow numbers will reach 1.7 million with an average herd size of over 100 cows (Teagasc, 2016a; DAFM, 2015a). A knock-on effect is that the additional dairy cows are expected to increase beef output by 5 to 10 percent (DAFM, 2015b). It is important to note that dairy-breed beef is sold at a lower price and, if dairy beef displaces suckler beef, then the overall value of the beef sector will decline, other things being equal.

2.4 The Economic Situation of Suckler Cow Farms

The Teagasc National Farm Survey (NFS) is the official source of data on farm income in Ireland. The NFS classifies farms into six farm types based on the Standard Output of the Farm.[2] Cattle rearing farms include those that stock suckler cows and produce beef breed animals. Figure 2 presents the average family farm income on cattle rearing farms in Ireland from 2000 to 2017. As can be seen average incomes are quite low, varying between €5,000 and €12,000 throughout the period. The average income in 2017 was €12,529. Furthermore, the reliance on direct payments is apparent; profit generated from the market place is negative throughout the period, meaning that the costs of production exceed the price received for outputs.

Figure 2: Family Farm and Market Income on Cattle-Rearing Farms, 2000 to 2017

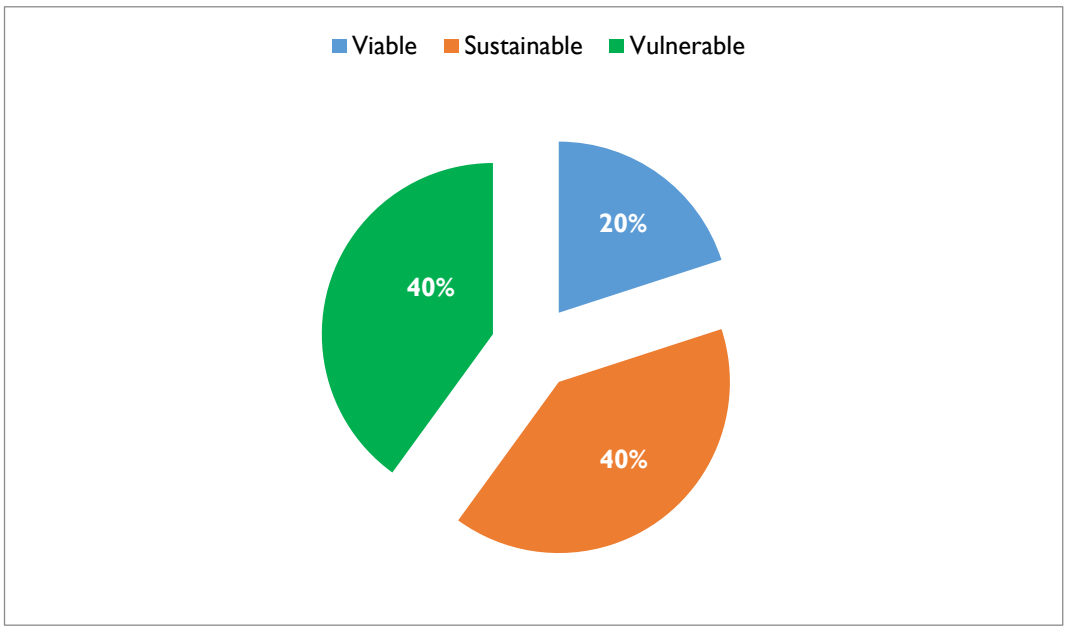


Source: Teagasc National Farm Survey (2018b).

[2] Further information on the methodology of the National Farm Survey can be found at www.teagasc.ie/rural-economy/rural-economy/national-farm-survey/

In addition to examining income levels it is also useful to consider the viability of cattle rearing farms. The viability framework employed by the Teagasc National Farm Survey defines a farm as being economically viable if the farm income can remunerate family labour at the minimum agricultural wage and provide a 5 percent return on the capital invested in non-land assets. Farms that are not economically viable are defined as sustainable if the farmer or the spouse has an off-farm job. Farms that are neither economically viable nor sustainable are classified as economically vulnerable. As shown in Figure 3, just 20 percent of cattle-rearing farms were classified as economically viable in 2016, a further 40 percent were classified as sustainable with the remaining 40 percent of cattle-rearing farms being economically vulnerable.

Figure 3: Proportion of Viable, Sustainable and Vulnerable Cattle Rearing Farms in Ireland, 2016



Source: Teagasc National Farm Survey (2017a).

Table 4 uses Teagasc National Farm Survey data from 2016 to examine profitability levels of suckler farming on a per-hectare basis. In 2016 total costs of production consume 101 percent of output value, yielding a net margin loss of €8 per hectare before direct payments. Again, this demonstrates that production costs exceed output prices, and that many farmers can only continue in production due to the provision of direct payments.

Table 4: Production Costs, Average Gross and Net Margins in € per hectare, 2015 and 2016: Single Suckling

	2015	2016	2016/2015 %change
Gross Output	**920**	**913**	**-1**
Concentrate Costs	125	127	+2
Pasture and Forage Costs	235	245	+4
Other Direct Costs	96	108	+13
Total Direct Costs	456	481	+5
Gross Margin	**464**	**432**	**-7**
Energy and Fuel	98	108	+10
Other Fixed Costs	348	332	-5
Total Fixed Costs	447	440	-2
Net Margin	**18**	**-8**	**n/a**

Source: Teagasc National Farm Survey (2017b).

In conclusion, the economic situation on Irish cattle-rearing farms is challenging, with a large number of households in a vulnerable position. Typically, production costs exceed output prices, and farms require direct payments to sustain their businesses. Without a substantial increase in beef prices and/or a major shift in efficiency levels, the vast majority of cattle-rearing farms will remain reliant on direct payments.

2.5 The Beef Supply Chain

The Irish beef supply chain (see Figure 4) can be analysed through five key stages: (i) farm inputs; (ii) production or farming; (iii) processing and packaging; (iv) branding, marketing and distribution; and (v) sales and retail (Heery *et al.*, 2016).

Despite the relatively poor economic position of cattle farms, they make an important contribution to the economy both in terms of the output they produce and in the inputs they consume. Table 5 presents an estimate of total input expenditure by specialist cattle farms, estimated using Teagasc NFS data on 19,952 cattle rearing farms and 27,025 cattle other farms. Including both direct and overhead costs, it is estimated that specialist cattle farms spend approximately €1.5 billion on farm inputs each year. This expenditure includes inputs that are typically purchased locally, such as feed, fertiliser, labour, veterinary products and general services. Almost €200 million of the overall expenditure relates to depreciation charges on buildings and machinery. Given that the data do not include large capital investments such as machinery purchase or the construction of new buildings, the depreciation charge acts as a proxy for these expenses.

Table 5: Estimates of Input Expenditure by Cattle Farms in 2016[3]

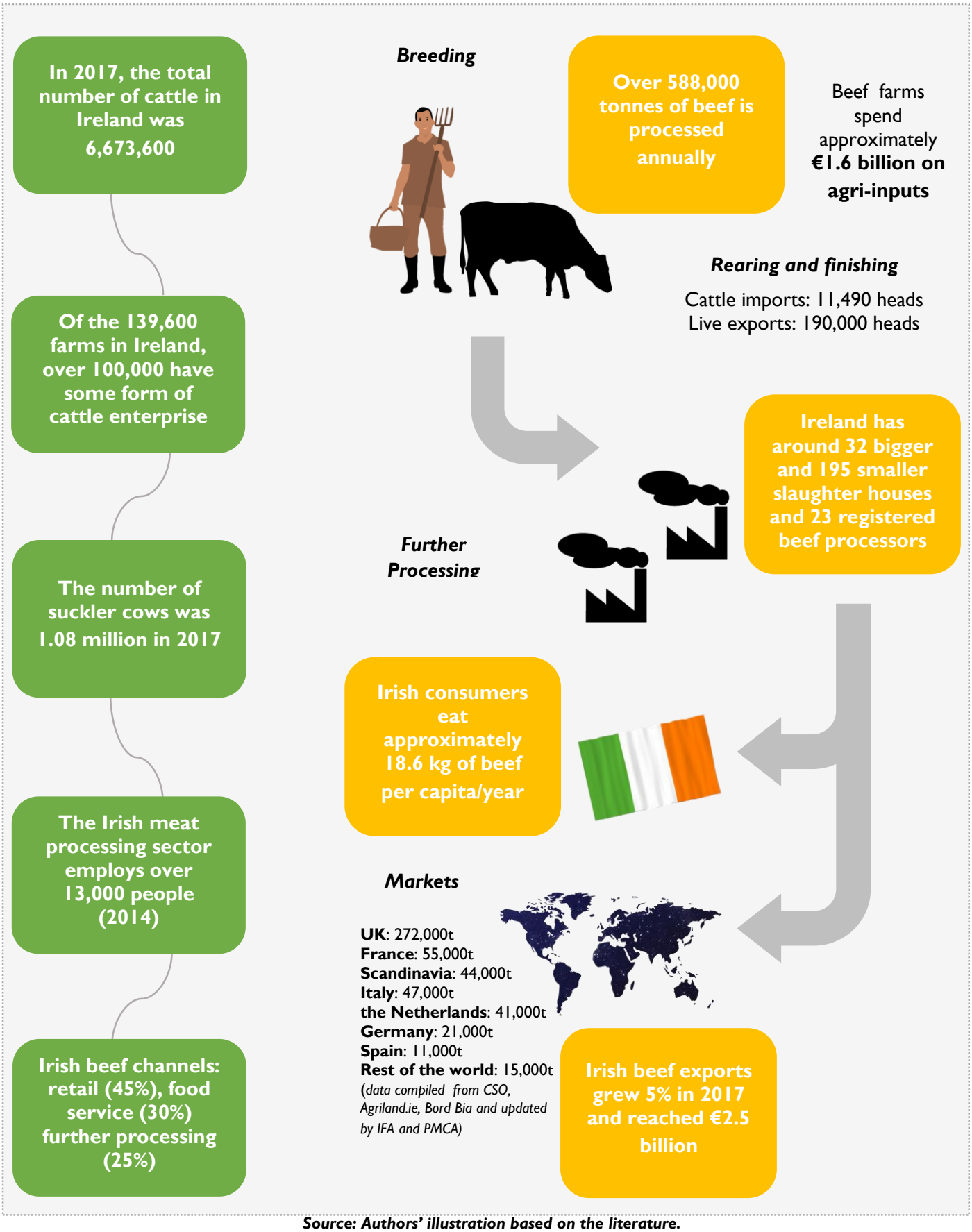
Input	€million
Purchased feed	255
Fertiliser	143
Crop protection and seed	20
Transport and Energy	278
Vet and AI	102
Labour	24
Land rent	56
Interest	26
Machinery, Land and Buildings Maintenance	238
Machinery and Buildings Depreciation	178
Other	175
Total	**1,496**

Source: Teagasc (2017c).

An input-output analysis conducted by Loughrey *et al.* (2012) found that the agricultural economy is highly local. For the County of Clare, the study concluded that cattle farmers in the county purchase and sell approximately 80 per cent of their livestock within the county, and rely upon Clare suppliers for almost 90 per cent of their inputs and overheads.

[3] Estimates include input expenditure associated with secondary enterprises on the farm such as sheep and/or crop production.

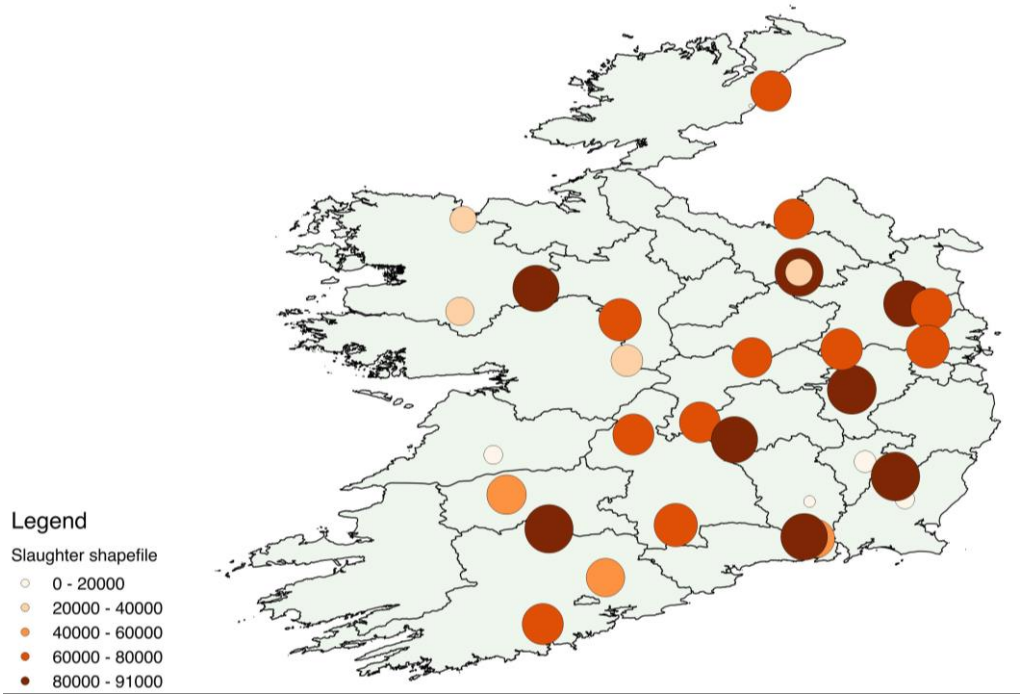
Figure 4: The Irish Beef Supply Chain



Source: Authors' illustration based on the literature.

The meat processing sector in Ireland, which includes beef, comprises approximately 32 major slaughtering facilities, which are approved for export from Ireland to local, EU and third-country markets and are supervised by the Department of Agriculture, Food and the Marine (see Figure 5) (DAFM, 2015). An additional 195 smaller slaughterhouses are supervised by the Local Authority Veterinary Service, and may export beef within the EU (DAFM, 2015). The map gives an indication of the location and size of these slaughterhouses.

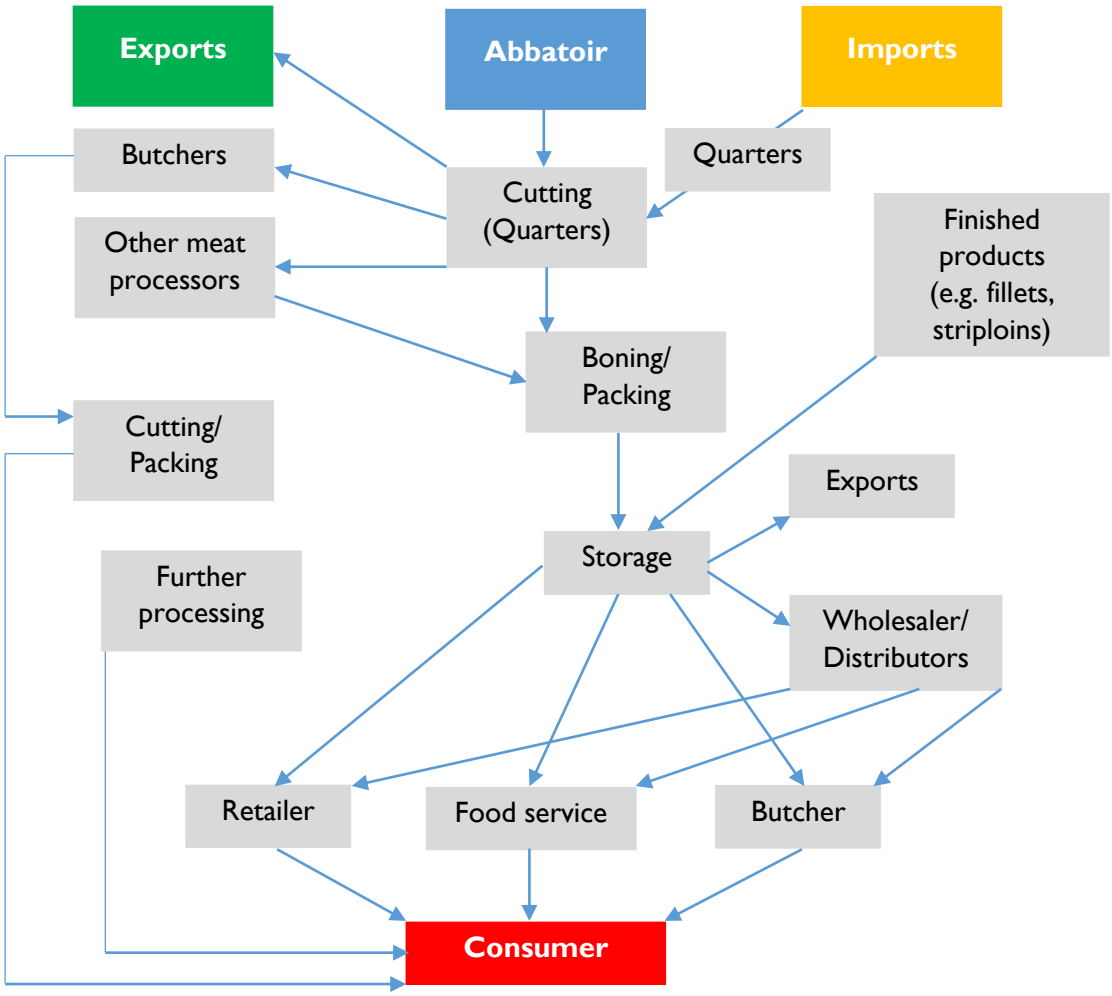
Figure 5: Major Slaughtering Facilities in Ireland based on size of Slaughter



Source: Authors' map based on data compiled from a number of online sources

In 2014, the Irish meat processing sector employed over 13,000 people (Hanrahan, 2016b). The sector has an important role in many rural areas where its factories often represent the largest local employer and the local residents rely on the employment and services generated by those factories (Meat Industry Ireland, 2015). The processing industry is undertaking significant investments in order to upgrade processing facilities, generate new revenues and jobs through value-addition, and successfully compete on the EU and global scale (Meat Industry Ireland, 2015). Figure 6 shows some of the value-adding processes, such as cutting, boning, portioning, packing and further processing which are part of the Irish beef supply chain. The meat processing industry has become more concentrated in terms of ownership and number of production plants in order to satisfy high pre-specified standards and hygiene requirements demanded by the large EU retail chains (SafeFood, 2008). The sector is now highly concentrated with the three largest processors having almost 60 percent of the market share.

Figure 6: Processing and Value-Addition in the Irish Beef Supply Chain



Source: SafeFood (2008).

2.6 Value and Destination of Export Markets

The value of Irish food and drink exports increased by over 13 percent in 2017 and reached almost €12.6 billion, which represents a growth of approximately 60 percent (or €4.7 billion) since 2010 (see Table 6) (Bord Bia, 2018b). The most important export destinations were the UK (35 percent or €4.5 bn), other EU markets, particularly Germany, France, the Netherlands and Belgium (33 percent or €4.1 bn) and international markets (32 percent or €4.0 bn) (Bord Bia, 2018b).

Relative to 2016, the value of Irish beef exports increased by 5 percent to approximately €2.5 billion in 2017 (Bord Bia, 2018b). An estimated 556,000 tonnes of Irish beef were exported, excluding live exports. The beef sector accounted for 20 percent of all Irish food and drink exports and contributed 9 percent of all export growth. Prepared foods, which includes

among other things beef-based processed food products, comprised a further 8 percent of Irish exports.

Table 6: Export Performance of the Irish Food and Drink Sector 2016 and 2017

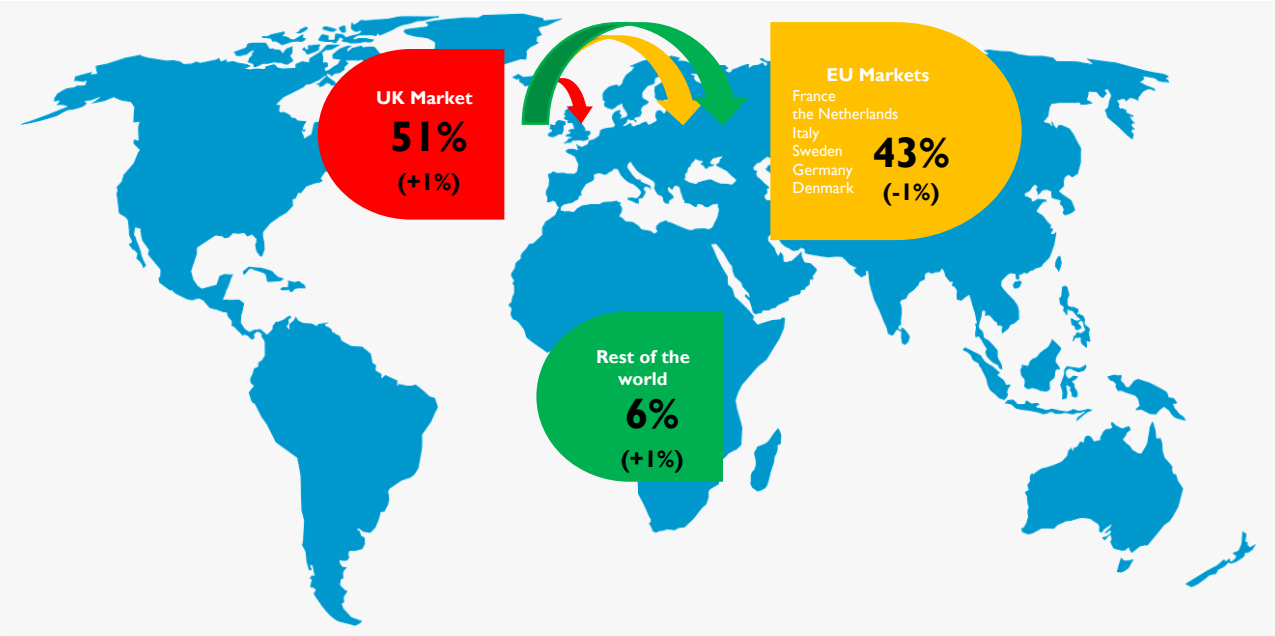
Sector	2016 (€ million)	2017 estimation (€ million)	% change 2017/16
Dairy	3,368	4,023	19%
Beef (included offal)	2,370	2,496	5%
Prepared foods	1,913	2,243	17%
Beverages	1,391	1,497	8%
Pigmeat	626	712	14%
Seafood	556	645	16%
Poultry	284	295	3%
Edible horticulture and cereals	230	230	0%
Sheepmeat	245	275	12%
Live animals	146	175	21%
TOTAL	**11,129**	**12,591**	**13.1%**

Source: Bord Bia (2018b).

The UK remained the most important destination for Irish beef exports in 2017, with a market share of 51 percent (Figure 7) (Bord Bia, 2018b). The other key EU markets for beef were France, the Netherlands, Italy, Sweden, Germany and Denmark. In international markets, Irish beef performed strongly in the Philippines, Hong Kong, Ghana, Israel, Saudi Arabia, Vietnam, Singapore and Thailand. The US market opened to Irish beef exports in 2015 after the 15-year ban caused by the BSE crisis, making Ireland the first EU country to be granted access to the US market post-crisis. In the 7 months to July 2018, the US imported 1,269 metric tonnes of fresh Irish beef, an increase by 19 percent over the same period in 2017 (USDA, 2018a).

In April 2018, China opened its market to Irish beef, and it is projected that, as a result of urbanisation, health trends and higher disposable incomes, the consumption of high-quality beef in China will increase in coming years (DAFM, 2018a). China is a growing export destination for Irish food products in general and Irish agri-food exports to China increased from around €200 million in 2010 to nearly €1 billion in 2017 (DAFM, 2018b). The opening of these two large and valuable markets presents opportunities for the Irish beef sector, which offer some counterbalance to the threat of Brexit.

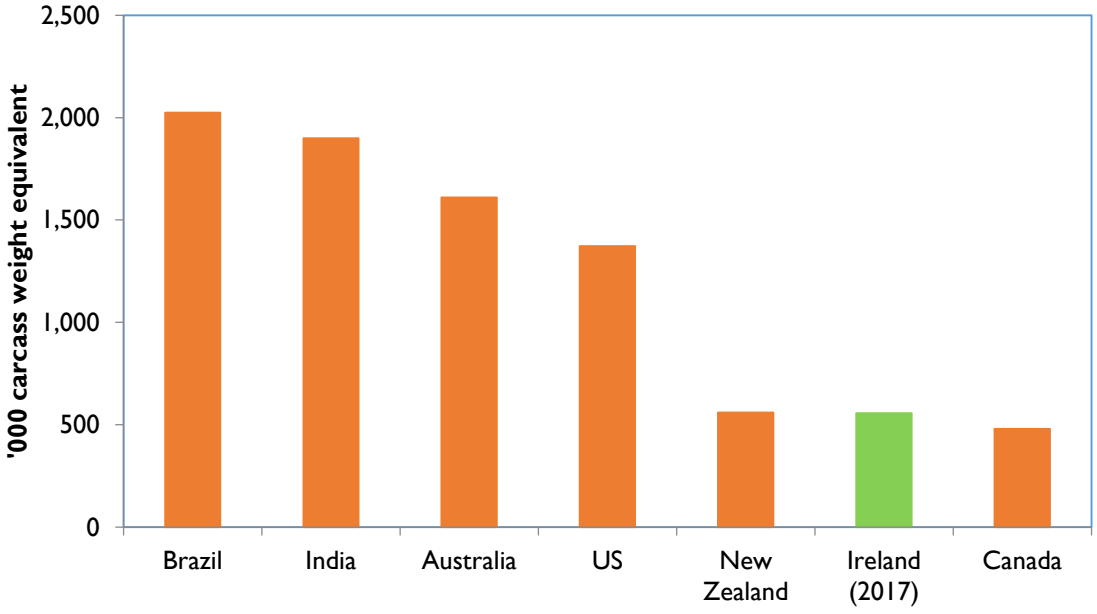
Figure 7: Destinations of Irish Beef Exports 2016 and 2017



Source: Derived based on data from Bord Bia (2018b). Percentages in brackets refer to the change in Irish beef export compared to 2016.

On the international stage Ireland is a major player, the sixth largest exporter of beef in the world and the largest in Europe. Figure 8 shows that Ireland trails behind only Brazil, India, Australia, the US and New Zealand.

Figure 8: Global Beef Exports 2018 (Forecast)



Source: USDA (2018b) and Bord Bia (2017).

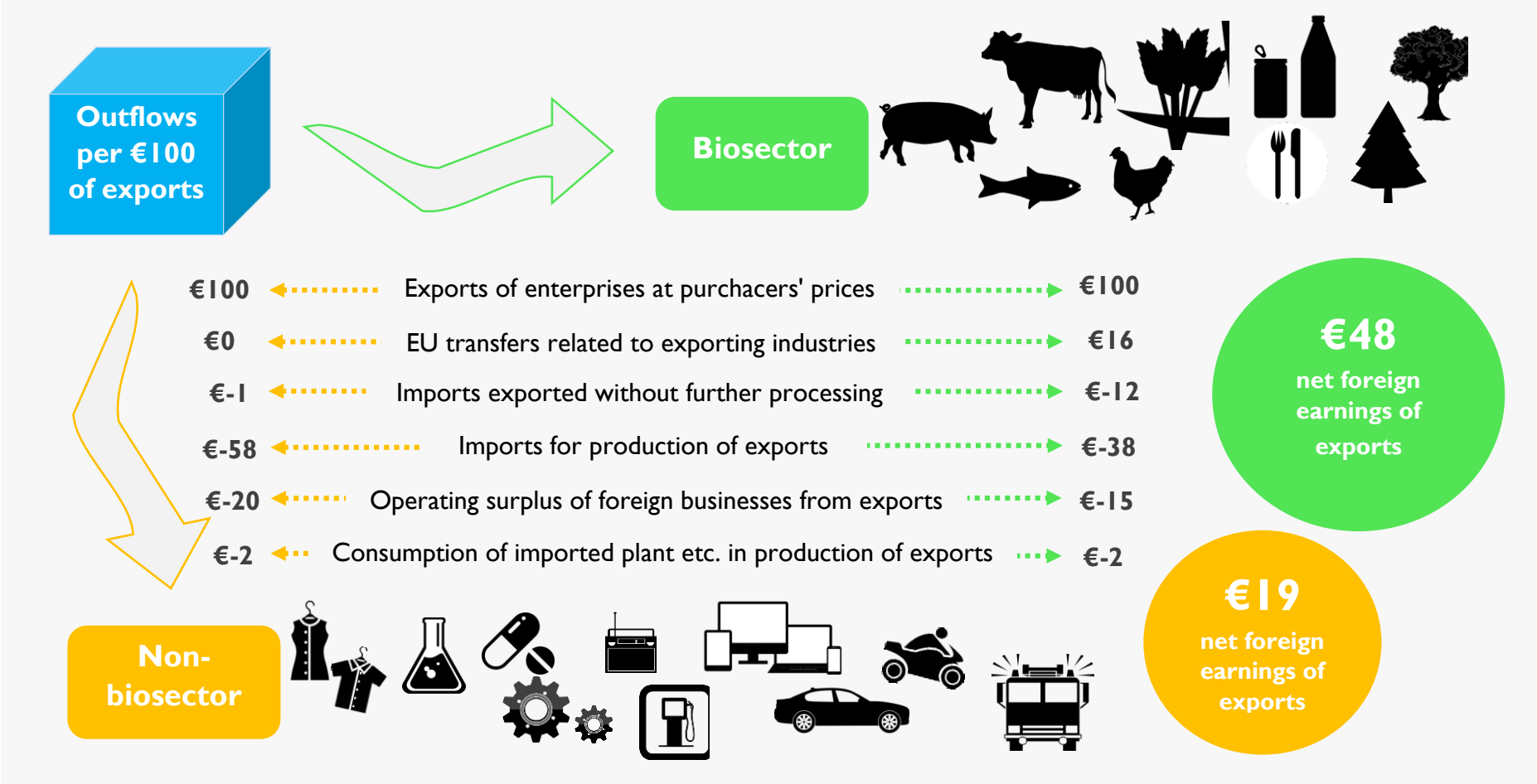
As pointed out above, the agri-food sector accounts for just over 10 percent of goods exports from Ireland. However, analysis conducted by Riordan (2008) demonstrated that the agri-food sector is a much larger contributor to foreign earnings. Riordan's analysis showed that every €100 of exports from the biosector, which includes agri-food, generated €48 in net foreign earnings, while the non-biosector contributed only €19 (Riordan, 2008) (Figure 9 and see the Appendix 3 for exhaustive list of industries in biosector and non-biosector taken into consideration in the analysis). The key reasons for such a large contribution from the biosector were lower import requirements per euro of exports, the prevalence of Irish-owned companies, and higher receipts of EU payments.

2.7 Live Exports from Ireland

The beef export figures cited above do not include the value of beef animals exported live from Ireland. Live cattle exports represent a significant market outlet and source of competition for certain categories of stock, particularly for male dairy calves, as well as high-quality weanlings from the suckler herd (Burke, 2016). The total number of beef animals exported live from Ireland fell from a record high of almost 350,000 in 2010 to less than 150,000 in 2016. In 2017, approximately 190,000 head were exported, of which calves were the most significant category (53 percent), followed by weanlings (15 percent), adult or finished cattle (14 percent) and store cattle (13 percent) (Bord Bia, 2018b). Irish calf exports increased by 40 percent compared to 2016 and reached about 101,000 head (Bord Bia, 2017). Cattle live exports in 2017 were valued at approximately €115 million. Adding this to the €2.5 billion of beef exports outlined brings the total value of beef exports to a figure in excess of €2.6 billion.

The key markets for Irish calves included the Netherlands (42,000 head), Spain (43,000 head), Belgium (5,000 heads) and France (in decline) (Bord Bia, 2018b). Although live cattle exports to Great Britain dropped by 6 percent in 2017 and reached only 6,000 head, this was offset by the 12 percent increase in cattle exported to Northern Ireland (27,000 head) and almost 30,000 animals exported to Turkey, which now accounts for 16 percent of Irish live cattle trade (Bord Bia, 2018b).

Figure 9: Contribution of the Biosector (including agri-food sector) and Non-biosector to Net Foreign Earnings of Exports, 2005



Source: Based on Riordan (2008).

2.8 Estimating the Total Value of the Beef Sector

Beef exports, including product and live exports, are valued in excess of €2.6 billion, and it is estimated that approximately 50,000 tonnes of Irish beef is consumed in Ireland. Based on the value secured for exported beef, it is estimated that domestic consumption of Irish beef is worth €230 million. This puts the overall output value of the Irish beef sector at €2.83 billion.

2.9 Conclusions

The beef sector in Ireland is a considerable one, accounting for over a third of all agricultural output and for over 20 percent of Irish food and drink exports. The agri-food sector in general accounts for 9 percent of total employment in Ireland and supports employment in a number of ancillary sectors, with over 13,000 employed in the meat processing sector. Beef exports are worth over €2.5 billion and are on the increase, with the recent opening of the Chinese and American markets for Irish beef.

The large beef sector is supported by over 1 million suckler cows. The suckler cow herd is scattered throughout the country but particularly dominates in the West. Over 80 percent of cows in the west are suckler cows, and over 90 percent in some counties, demonstrating the important regional presence of this sector.

There are 77,738 specialised beef farms in Ireland. The economic situation on these farms is challenging. On average, costs of production exceed output prices, and the reliance on direct payments is high. Without a substantial increase in beef prices and/or significant improvement in efficiency levels, the vast majority of cattle farms will continue to rely on direct payments. Despite the poor economic situation, cattle farms make a considerable contribution to the local economy. It is estimated that cattle farms spend almost €1.5 billion annually on agri-inputs.

Chapter 3: Policy Developments and Challenges Facing the Irish Beef Sector

3.1 Introduction

There are a number of challenges and policy developments looming in the short and medium term for the agri-food sector in general and the beef sector in particular. The following chapter examined some of these issues and discusses implications for the beef sector.

3.2 Climate Change Policy

Feeding the world's growing population while also trying to limit the impact of agriculture on climate change is one of the greatest challenges facing modern society. Ireland has signed up to a number of agreements that aim to reduce greenhouse gas emissions. Under the EU Effort Sharing Decision (Decision No 406/2009/EC), Ireland was given a legally binding target to reduce non-ETS (emission trading scheme) greenhouse gas emissions to 20 percent below the 2005 level by 2020. However, estimates by the EPA (2017) suggest that the country is likely to achieve only a 4 to 6 percent reduction by 2020, and that Ireland will be financially penalised for not meeting these targets. In the longer term, Ireland is committed to reducing greenhouse gas emissions further.

Almost one third of greenhouse gas emissions generated in Ireland comes from the agricultural sector. Ireland is relatively unusual in this regard as on average the agricultural sector accounts for 10 percent of emissions across the EU28. The Irish position reflects the fact that the agricultural sector is large relative to other sectors, and is dominated by livestock which is more emissions-intensive than crops. Furthermore, the animal population is large relative to the human population, making emissions from the transport and residential sectors relatively smaller.

With agriculture being such a large emitter of greenhouse gas emissions, it is clear that the sector will have to become a part of Ireland's efforts to tackle climate change. Enteric fermentation by cows is one of the principal sources of greenhouse gas emissions, and as such, greenhouse gas emissions per animal or per food product are coming under scrutiny. Due to the high levels of methane emitted by cows, animal-based food products are relatively carbon-intensive.

Government policy currently aims at improving the carbon footprint of beef production through programmes such as the Beef Data Genomics Programme. Such programmes have been relatively successful, and by international standards the carbon footprint of beef production in Ireland is quite low, rated the fifth lowest in Europe in 2010 (Leip *et al.*, 2010). These programmes and the carbon performance of the beef sector are discussed in more detail in Chapter 6. Despite relatively low carbon footprint in Ireland, the absolute level of greenhouse gas emissions remains a problem, especially with the dairy sector in expansion mode and dairy cow numbers and their progeny continuing to grow, and further policy

options are likely to be considered in the near future. Debate continues on how best to tackle this issue in a way that allows Ireland to meet its environmental commitments and gives the agri-food sector and rural Ireland the opportunity to prosper.

3.3 Brexit

On 23 June 2016 the majority of the British voters supported Britain's withdrawal from the European Union. Negotiations on exactly how this exit will occur commenced on 29 March 2017 when the UK triggered Article 50 of the Treaty on European Union issuing notice to withdraw from the Union. Negotiations on Phase 1 concluded in December 2017. This Phase considered the financial terms of the withdrawal, the rights of EU citizens living in the EU, and the border between Ireland and Northern Ireland. At the time of writing, negotiations on Phase 2 are underway; this Phase covers the arrangements for transition towards the UK's withdrawal, together with a framework for the future UK/EU relationship. A transition period up to December 2020 has been agreed between the UK and EU, during which time the UK will remain part of the single market and customs union. The UK will be free to negotiate new trade deals during this period, but such deals will not come into effect until 2021 at the earliest.

The degree to which the UK will develop new trade deals and deviate from the existing single market arrangements will determine the magnitude of the impact of Brexit on the Irish beef sector. The final agreement will fall somewhere along the spectrum of the Soft to Hard Brexit. The Copenhagen Economics Group in their 2016 report analysed four long-term scenarios which effectively encompass the best to worst case scenarios. The two extreme scenarios are:

- **European Economic Area (EEA) scenario**: trade arrangements similar to those between the EU and Norway and Iceland, including duty-free trade on most products, with tariffs on some sensitive products such as food. Even under this scenario border inspections on EU-UK trade will add customs costs, but the risk of regulatory divergence for both goods and services is low.

- **World Trade Organisation (WTO) Scenario**: trade governed by WTO rules, whereby the UK and the EU will impose Most Favoured Nation (MFN) tariffs on each other's goods where these are not bound by existing plurilateral agreements or arrangements. In addition, the EU and the UK will continue to use tariff rate quotas both between them and with third countries.

The Copenhagen Economics report concludes that Brexit will have negative economic implications for the Irish economy in all scenarios analysed. Even in the best case (EEA) scenario, Irish GDP contracts by 2.8 percent and exports by 3.3 percent, while in the worst case (WTO) scenario Irish GDP contracts by 7 percent and exports by 7.7 percent.

The Irish agri-food sector is particularly vulnerable to a Hard Brexit because of the volume of trade between Ireland and the UK, the very high WTO MFN tariffs that apply to food

products, and the reliance of the sector on direct payment support which is funded from the EU budget. In 2017, Ireland exported €4.5 billion of food products to the UK, comprising approximately 35 percent of all food exports in 2017. This was a slight reduction on previous years due to growth in other markets and due to currency movements reducing the value of exports to the UK. Almost 51 percent of beef exports went to the British market in 2017, making this sector particularly vulnerable to a change in trade agreements under a Hard Brexit scenario. The sector is also vulnerable to a contraction of the EU budget. The UK is a net contributor to the EU budget and it is estimated by Matthews (2018) that the UK's withdrawal from the EU will lead to a 10 percent reduction in the funding available for the Common Agricultural Policy, assuming that contributions from other Member States do not increase to bridge the difference.

Analysis conducted by Teagasc (2017d) estimated the impact of price and direct payment shocks, arising from a Hard Brexit scenario, on farm income in Ireland. The static analysis used price shock information from Van Berkum *et al*. (2016) for various agricultural commodities, and assumed a 10 percent pro rata reduction in the value of direct payments made to farmers. The results show a 36 percent reduction in income levels on cattle-rearing farms under a Hard Brexit scenario. It should be borne in mind that this reduction comes on already very low-income levels. The analysis concludes that the percentage of economically viable cattle-rearing farms would fall from approximately 20 percent in the no-Brexit situation to about 10 percent under a Hard Brexit scenario. Clearly Brexit represents a major challenge for the Irish beef sector.

3.4 Common Agricultural Policy (CAP) Reform

On 1 June 2018, the European Commission presented legislative proposals on the future of food and farming. Given the budgetary pressures arising from Brexit and the demands to spend more on Union-level defence, security and migration, the announcement included an indication that the funding for the CAP would reduce by approximately 5 percent. The proposals are centred around 9 objectives: fair incomes for farmers, increased competiveness, realanced power in the food chain, climate change action, environmental care, landscape and biodiversity preservation, generational renewal, vibrant rural areas and food and health quality protection.

The proposal aims for better targeted support by:

- reducing direct payments to farmers in excess of €60,000 and capping for payments above €100,000 per farm (labour costs will be taken fully into account)
- providing a higher level of support per hectare for small and medium-sized farms
- allocating a minimum of 2 percent of direct support payments for young farmers, these can include an increased 'installation allowance' of up to €100,000
- ensuring that only genuine farmers receive support

The proposal aims for improved environmental outcomes by:

- preserving carbon-rich soils through protection of wetlands and peatlands,
- introducing obligatory nutrient management tools to improve water quality, reduce ammonia and nitrous oxide levels, and
- crop rotation instead of crop diversification.

Direct payments will be conditional on enhanced environmental and climate requirements. Furthermore, farmers will have the possibility to contribute further and be rewarded for going beyond mandatory requirements. EU countries will develop voluntary eco-schemes to support and incentivise farmers to observe agricultural practices beneficial for the climate and the environment. Member states will also have the option to transfer up to 15 percent of their CAP allocations between direct payments (Pillar I) and rural development (Pillar II) – and in either direction – to "ensure that their priorities and measures can be funded".

A 5 percent reduction in the CAP budget will translate into lower direct payments. The magnitude of the reduction in direct payments is difficult to estimate at this stage, as it will depend on (i) how the overall reduction in the budget will be allocated at a Member State level, (ii) what is clawed back from recipients of large payments and (iii) the allocation between Pillar I and II. In any case, it is most possible that payments to suckler farmers in Ireland will decline, and this will have a direct negative impact on farm incomes.

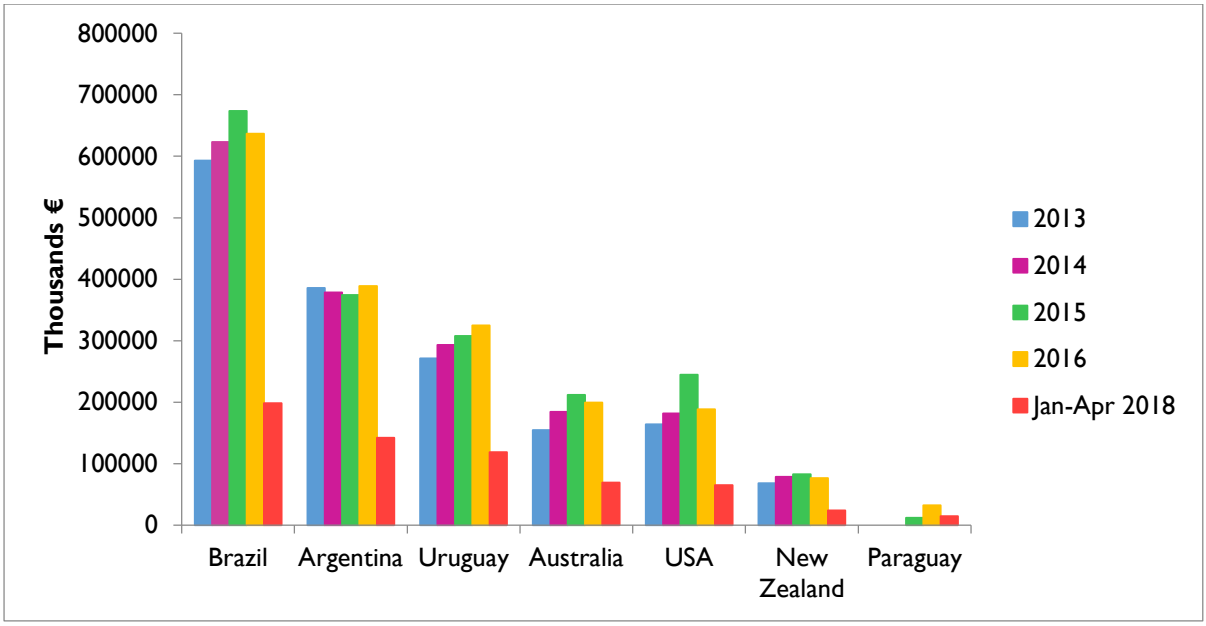
On a positive note, recent research conducted by the European Commission suggests that there is broad and strong support for retaining and expanding the CAP. A Eurobarometer study conducted in December 2017 examined the attitudes of over 28,000 EU citizens, 1,000 of which were Irish, to agriculture and the Common Agricultural Policy. More than 90 percent of EU citizens think that agriculture and rural areas are important to the future of Europe, with 53 percent saying very important. The sentiment is even stronger in Ireland, with 57 percent stating that agriculture and rural areas are very important. A majority of respondents believed that agriculture and food policy was best managed at a European level rather than national level. Furthermore, 61 percent of EU citizens and 64 percent of Irish citizens strongly agreed that the CAP benefits all citizens and not only farmers. Only 10 percent of Irish citizens disagreed with this statement. In relation to the financial support provided to farmers, survey participants were given information about the aggregate size of the budget for the CAP and were asked if they felt it was appropriate. In response, 44 percent of EU and 43 percent of Irish citizens felt that support to farmers should increase, nd only 8 percent of Irish citizens felt that support to farmers should decrease. When questioned about the role of farmers, participants replied that in their opinion producing high-quality, safe food and ensuring the welfare of animals were the two most important functions of farmers.

3.5 Mercosur

At the time of writing, the EU and the Mercosur (Argentina, Brazil, Paraguay, Uruguay and Venezuela) countries are engaged in trade negotiations. Together, these Mercosur countries represent the world's seventh largest economy. It seems that the EU is prepared to offer an increase in market access for Mercosur beef to the European market, but this is contingent

on the EU securing concessions on better market access into Mercosur for EU-manufactured cars and dairy products, the inclusion of maritime services in the deal, more favourable requirements on "rules of origin", and access to public procurement at the sub-federal level. Increased volumes of Mercosur beef entering the EU market would be likely to place downward pressure on the internal EU beef price and thus further reduce the profitability of the Irish beef sector.

Figure 10: EU Beef Imports by Source



Source: European Commission (2018).

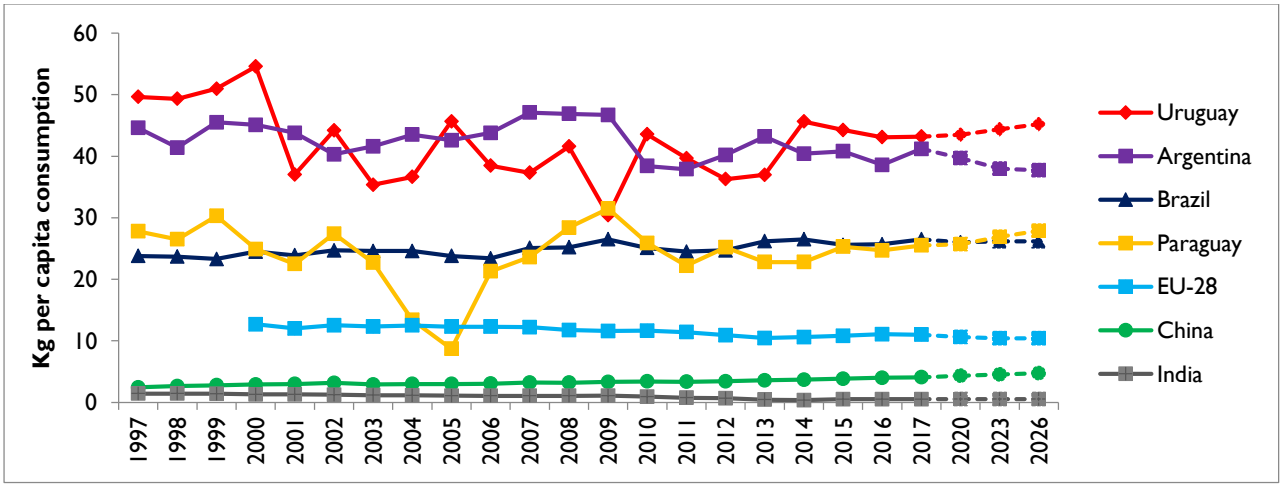
In 2016, the EU Commission published a report examining the cumulative effects of 12 possible trade agreements for the EU agri-food sector. The analysis considered the implications of trade policy reform with 12 countries USA, Canada, Mercosur, Australia, New Zealand, Japan, Vietnam, Thailand, Turkey, Mexico, Philippines and Indonesia (see Figure 10). Based on a set of assumptions about the outcome of such reforms, the analysis suggests that some agricultural sectors are more vulnerable than others, with dairy and pigmeat benefitting and beef at risk. In particular, it was estimated that imports of beef from the Mercosur countries to Europe would increase. Deterioration in the balance of trade is likely to result in reduced beef prices within the EU, other things being equal. It should also be noted that this study was conducted before Brexit, and if the Brexit effect was considered it would make the negative impacts larger.

3.6 Consumer Trends

Vegetarianism and veganism has attracted a great deal of media coverage in recent times. Despite this, meat consumption remains high, and the numbers opting for vegetarian diets is low. Although official data are difficult to secure, online sources suggest that just 6 percent of consumers in Ireland are vegetarians, while less than half of 1 percent of British consumers are vegans. In 2017, consumption of beef and veal in the EU-28 was 11 kg per capita (OECD,

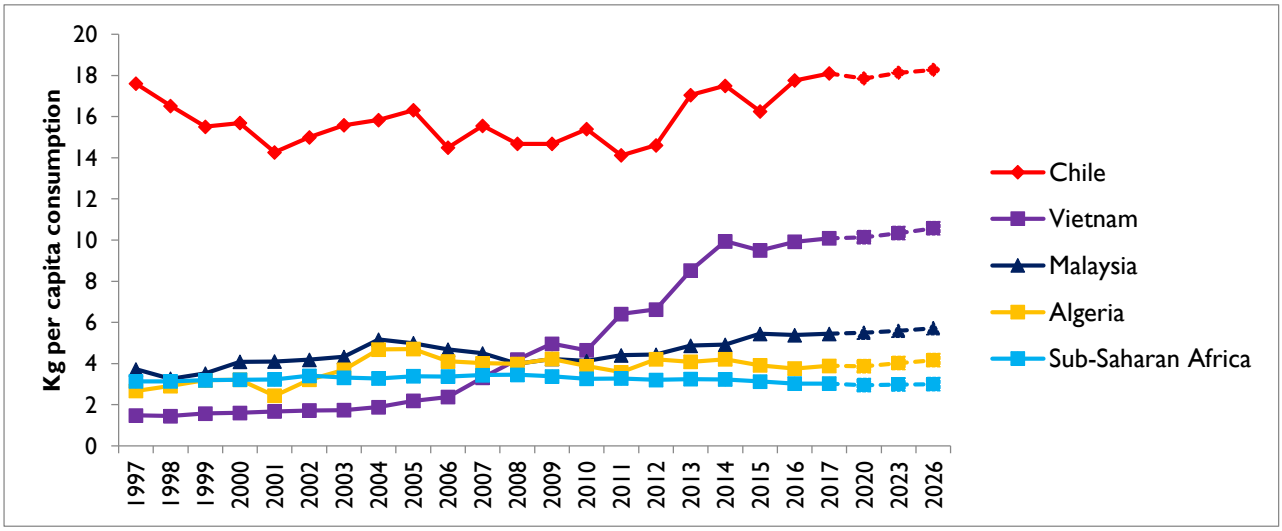
2018). In addition, beef and veal consumption in EU-28 was higher than the world average in 2015 (6.4 kg per capita) and 2016 (6.5 kg per capita) (OECD, 2018). Consumption of beef and veal per capita in the EU-28 has decreased slightly in the last decade, and this trend is likely to continue, from 10.7 kg in 2018 to 10.6 kg in 2020 and 10.4 kg in 2026 (OECD, 2018) (see Figure 11). An increase in beef and veal consumption per capita is expected to occur in Uruguay, Brazil, Paraguay and China. The OECD/FAO agricultural outlook projects global consumption of beef to grow by 9 percent by 2026, with growing beef demand linked to higher incomes and a shift towards increased proteins from animal sources in diets.

Figure 11: Consumption of Beef and Veal in kilograms per capita 1997-2017 with Projections for 2020, 2023 and 2026



Source: OECD (2018).

Figure 12: Consumption of Beef and Veal in kilograms per capita 1997-2017 in Developing Countries with Projections for 2020, 2023 and 2026



Source: OECD (2018).

Despite this expected slight decline in beef and veal consumption in the EU-28, a growth in beef and veal consumption is projected for developing countries, where consumption has fluctuated over the past 20 years but is expected to increase steadily between 2020 and 2026 (OECD, 2018) (see Figure 12). Middle-class world population is projected to grow from 3.2bn in 2017 to 5.2bn in 2030 and spending on meat and poultry consumption to rise from $35 trillion in 2017 to $51 trillion by 2030 according to Bord Bia. For example, Chile already has higher beef and veal consumption per capita compared to EU-28 (in 2017, 18 kg and 11 kg respectively) and the demand for beef and veal is likely to increase. Vietnam has experienced spikes in consumption since 2013, and in 2026 beef and veal consumption per capita will surpass the levels in the EU (OECD, 2018). Growing beef markets in third countries present significant opportunities for the Irish beef sector, especially in the context of the mature nature of the EU market and potential issues in the British market following Brexit.

3.7 Conclusions

There are a number of issues looming that may impact negatively or positively on the future development of the beef sector in Ireland. The future evolution of climate change policy is a major unknown on the horizon. Decisions that the Irish government must make in order to ensure compliance with international agreements may impact negatively on the future sustainability of the sector. Brexit is another major threat to the beef sector - the significant reliance of the beef sector on the UK market makes it more vulnerable to changes in trade policy. The ultimate impact of Brexit is as yet unknown until there is certainty about future UK/EU trade policy. On the positive side, a number of international markets have recently opened for Irish beef and the outlook for beef consumption globally is positive.

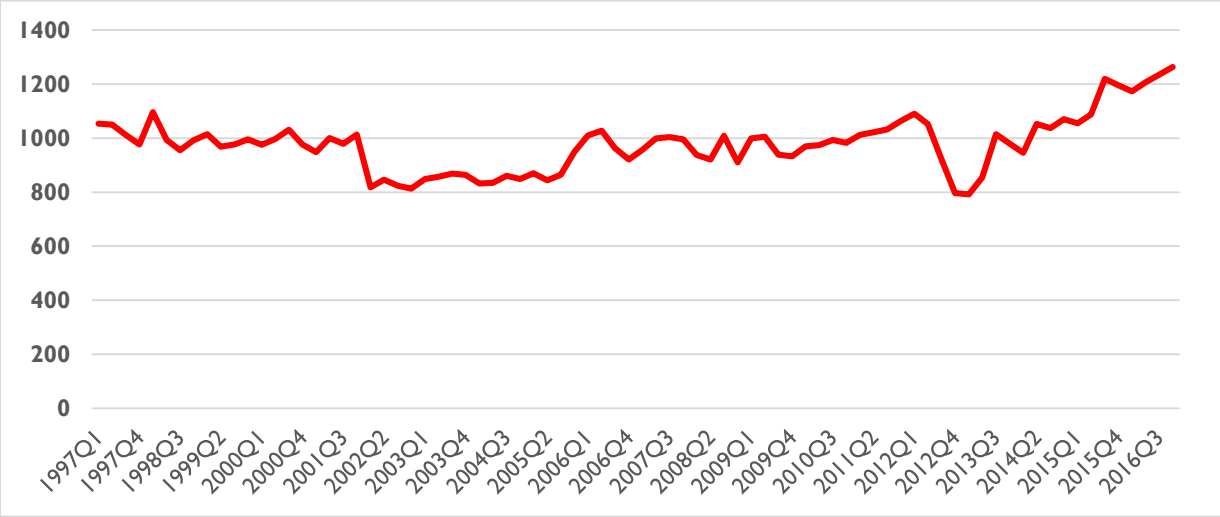
Chapter 4: Wider Economic Impacts of the Beef Sector in Ireland

4.1 Introduction

This chapter considers the wider economic impact of the beef sector. It begins by providing some context of the importance of the agricultural sector to the wider Irish economy. It then presents a series of multipliers to identify the impact of the sector on the Irish economy. Specifically, it is used to consider the impact of an expansion or contraction in the output of the agricultural sector, and beef in particular, on the output of the wider economy and on employment at both national and regional levels.

The quantity of output attributed to the Irish agriculture, forestry and fishing sector has remained relatively constant since 1997, as shown in Figure 13. However, as a share of total GDP it has been in continuous decline over the same period (CSO, 2018c). Given that output levels in agriculture are relatively stable, this continual decline is due to the faster expansion of other sectors of the Irish economy.

Figure 13: GDP Agriculture, Forestry and Fishing, Ireland, 1997-2016

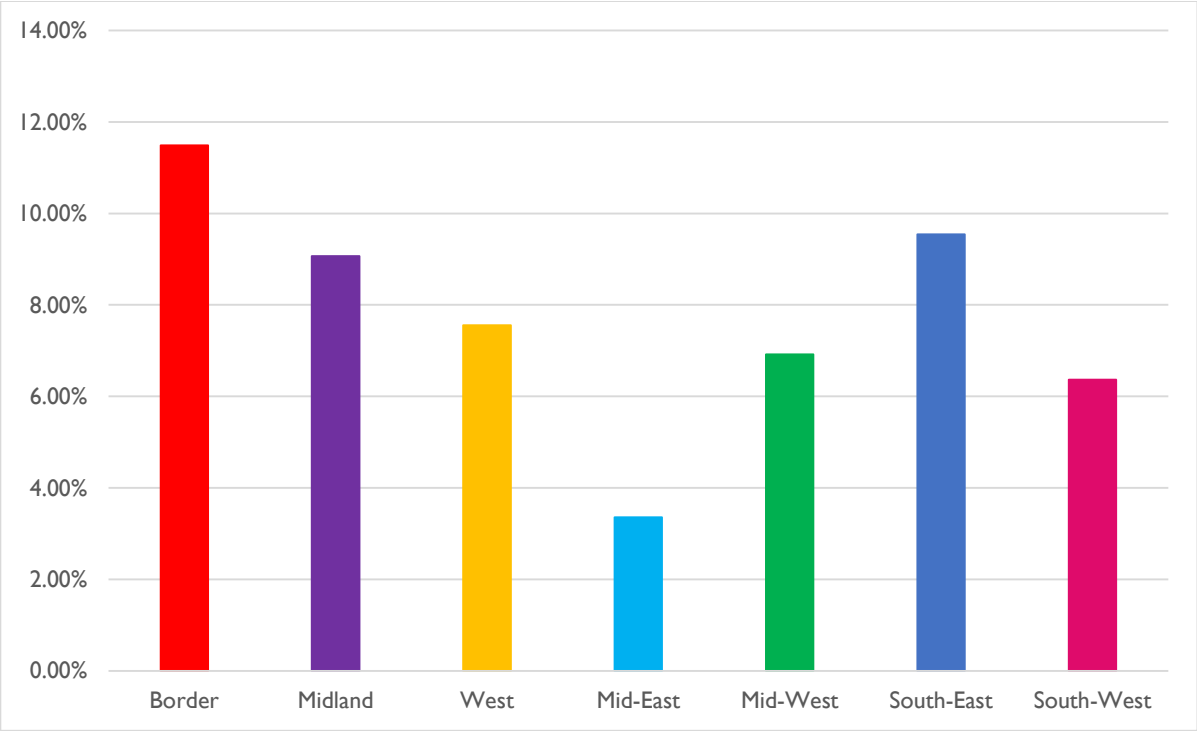


Source: CSO (2018c).

In terms of employment, the number of people employed in the agriculture, forestry and fishing sector has also been in decline, with a notable exception since the economic crisis where the sector regained some of the losses it had seen in the 2008-2012 period due to the recession (CSO, 2018d). However, as a share of total employment, the agriculture, forestry and fishing sector has seen an almost continuous decline - again with a slight recovery in 2012 (CSO, 2018d).

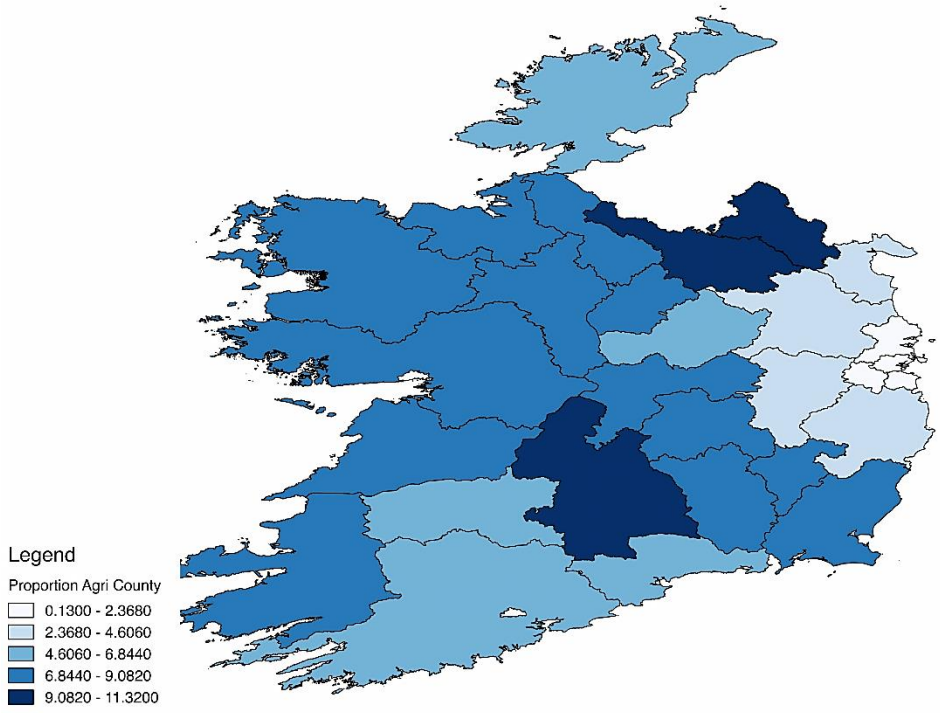
However, the overall figures hide a strong regional imbalance in the importance of agriculture, forestry and fishing to regional economies. In the border region, 11.49 percent of employment is in agriculture, forestry and fishing (Figures 14 and 15), and this sector is also relatively more important, compared to the national average, in the Mid-West, the South-East and the Midlands. This highlights the importance of the sector outside the greater Dublin area.

Figure 14: Shares of Persons aged 15 years and over in Employment in Agriculture, Forestry and Fishing in 2017 Q2



Source: CSO (2018e).

Figure 15: Percentage of Employment in Agriculture, Forestry and Fishing by County



Source: CSO (2016).

4.2 Estimating the Output and Employment Impact of Agriculture Using Multiplier Analysis

Multipliers provided by the CSO can be used to consider the impact of the agricultural sector on the Irish economy. A number of previous studies have used output multipliers to consider the economic importance of the agri-food sector in general as well as specific sub-sectors, for example O'Connell and Phelan (2011), Miller *et al.* (2014), Renwick (2013) and O'Connor and Keane (2014). In this paper, multipliers are based on official 2011 input-output tables, the most recent ones available, further detail is available in Appendix 1. Multipliers work on the assumption that if there is an increase in final demand for a particular industry's output, then that industry increases output to meet that demand (the direct effect) but in doing so it also stimulates other sectors up the supply chain (the indirect effect). As a result of the direct and indirect effects, the level of household incomes throughout the economy increases due to increased employment and/or higher wages, and a proportion of this increased income will be re-spent on final goods and services (the induced effect) (Scottish Government 2018). This chapter focuses on the total effect of the output multipliers and employment multipliers. The output multiplier shows the effect on output of a one unit increase in output in a particular industry. The employment multiplier shows the impact of a one unit increase in output on employment.

Table 7 presents output and employment multiplier estimates for a variety of broad industrial sectors.

Table 7: Output and Employment Multipliers

Sector	Output Multiplier *Impact of €1 increase in output*	Employment Multiplier *Impact of €1m increase in output*
Agriculture, forestry and fishing	1.44	16.23
Manufacturing	1.19	2.90
Construction	1.53	17.37
Distribution, transport and communication	1.27	10.64
Business services	1.31	3.35
Other services	1.28	16.50

Source: Derived from the CSO (2014) Input-Output Tables and CSO (2012b) Employment Figures.

The CSO does not provide a detailed break-down of multipliers for the agricultural sector, but instead provides a multiplier for agriculture, forestry and fishing sector as a whole. Both the output and employment multipliers for the agriculture, forestry and fishing sector are relatively large compared with other sectors (being behind only construction in terms of output multipliers, and behind construction and other services in terms of employment multipliers). The output multiplier of 1.44 suggests that each additional euro of output produced in the agriculture, forestry and fishing sector generates €1.44 of output in the economy overall. This can be broken down into a direct effect of €1.19 and an indirect effect of €0.25. The employment multiplier implies that for an increase of 1 million euro in output 16.23 extra jobs are created.

Identifying the Sector-Specific Output Multiplier for the Beef Sector

In order to estimate the multiplier for the cattle sector in isolation, rather than for the overall agriculture, forestry and fishing sector, we implement a disaggregation technique based on Lindner *et al.* (2013). In this approach, we identify the contribution of beef to the overall agriculture, forestry and fishing sector and use this proportion to divide each of the columns in the Input-Output table between these two sectors. In doing so, we use the appropriate techniques to ensure that the overall use of inputs etc. in the beef sector and in the remaining agriculture, forestry and fishing sector sum to the previous totals for total agriculture, forestry and fishing. The estimate we obtain is approximately 2.11 for the beef sector multiplier. Using different data, Miller *et al.* (2014) obtained a multiplier for the cattle sector of 2.49. While our multiplier is smaller than theirs, different techniques and data were used to generate both.

This suggests that a one euro change in output in the beef sector will have (based on our figures) approximately a €2.11 impact on the economy.

In his 2013 study Renwick states that each €1 of support in direct payments to cattle farms underpins €4.28 of aggregate output in the Irish economy. He arrives at this estimate by applying his estimated output multiplier to beef output arriving at an aggregate output figure of €5.18 billion in 2012 and dividing this by €1.21 billion of direct payments which includes the total SPS payments plus a share of other payments made in 2012. Using a similar approach, the equivalent output figure based on the analysis here is €4.98 billion, based on a beef sector output of €2.361 billion and a multiplier of 2.11, suggesting each euro of direct payments still underpins in excess of €4 of aggregate output in the Irish economy.

4.3 Estimating the Output and Employment Impact of Agriculture, Forestry and Fishing on a Regional Basis Using Multiplier Analysis

Given the uneven regional distribution of agricultural employment across regions, as emphasised in Figure 14, it is worth considering regional output and employment multipliers to assess whether the importance of the sector varies spatially in stimulating local regions. However, no spatially disaggregated multipliers are produced by the CSO. A number of authors have generated spatially disaggregated multipliers but these have been at a very aggregated spatial level (McFeely, 2011). Here we create regional multipliers for agriculture, forestry and fishing sector for Ireland at the NUTS3 level of regional disaggregation. The method used is that of the simple location quotient. The technical appendix provides an overview of how this process was completed. Table 8 presents the regional agriculture, forestry and fishing multipliers for Ireland. Again both output and employment multipliers are generated.

Table 8: Regional Output and Employment Multipliers for Agriculture, Forestry and Fishing

NUTS3 Region	Output Multiplier	Employment Multiplier
Border	1.44	16.17
Midlands	1.44	16.17
West	1.44	16.16
Dublin	1.02	11.41
Mid-East	1.29	14.52
Mid-West	1.44	16.18
South-East	1.44	16.15
South-West	1.44	16.18

Source: Based on CSO (2014) Input-Output Tables and CSO (2012b) Employment Figures.

Note: The approach we have used essentially assumes that the multiplier may equal the national multiplier, but cannot be bigger than the national multiplier. We note that Miller and Blair (2009) highlight that in the regionalization the LQ is considered as an indicator of regional self-sufficiency. As long as LQ > 1 the region is relatively specialized and it can cover its own demand locally. If this is the case, we do not adjust the national coefficients. If LQ < 1 the region needs to import and is not self-sufficient. In this case, the regionalization is carried out as detailed in the Appendix.

We can observe in Table 8 that there is variation in the regional output and employment multipliers. The main differences are for the Dublin and Mid-East region which have a lower concentration of agriculture, forestry and fishing employment relative to total employment (as emphasised in Figure 14). This suggests that stimulating output in the agriculture, forestry and fishing sector in regions outside of Dublin and the Mid-East will result in greater returns in terms of output and employment than in those two regions.

4.4 Conclusions

While the relative importance of the agriculture, forestry and fishing sector has been in decline in terms of its overall importance for GDP and employment nationally, it has maintained importance in regions outside the greater Dublin area. The multiplier analysis shows that the output and employment impacts of changes in the agri-food sector are greater than for most other sectors. When considering the beef sector in isolation, we estimated an approximate multiplier for this sector to be greater than for the agriculture, forestry and fishing as a whole, at, 2.11 in comparison to 1.44, which means that an increase in output in the beef sector generates more economic activity than a comparable increase in other agri-food sectors.

There is also evidence to suggest that the multiplier effects for output and for employment are greater for the agriculture, forestry and fishing sector in particular regions, especially outside of Dublin as one would expect. It was not possible, within the scope of this analysis,

to disaggregate the regional sector multipliers into subsectoral ones in order to show the regional impact of changes in the cattle sector. However, one would expect that the beef multiplier for the regions would also be greater than general sector multiplier.

Chapter 5: Societal Impact of the Beef Sector in Ireland

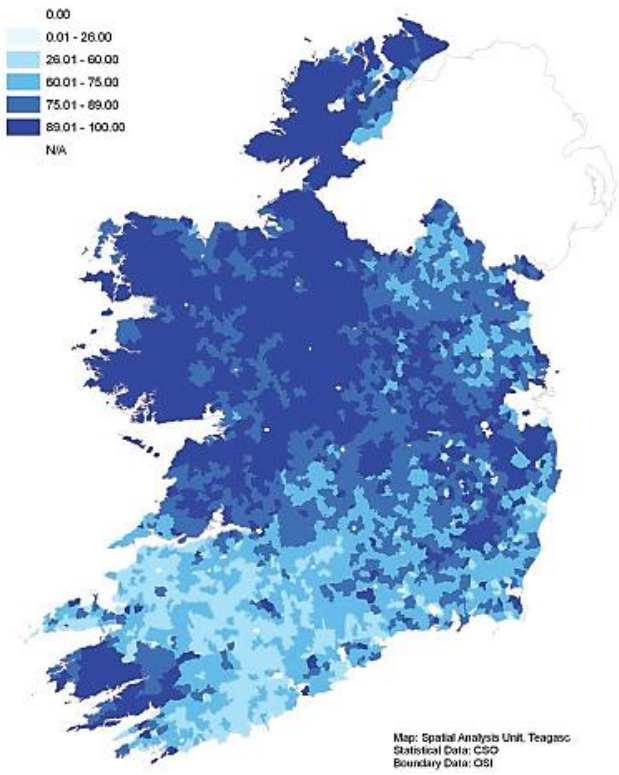
5.1 Introduction

The economic contribution of the beef sector is evident from the analyses presented in previous chapters. This is especially so in the marginal areas in Ireland, along the Western seaboard and in the Border region, where beef farming is most prevalent and often where there is little other economic activity. In addition to the important economic contributions that suckler farming makes to these marginal areas, considerable non-economic benefits are also generated for wider societal gain. This chapter explores the non-economic impact of the Irish beef sector. Particular emphasis is paid to the importance of the positive impact that farmers have on rural society, the public goods emerging from agricultural production, and how these public goods support rural tourism.

5.2 Presence in Rural Areas and Contribution to a Vibrant Rural Society

It is sometimes quoted anecdotally that there is a suckler farmer in "every parish in Ireland". Of course, it is difficult to prove this with verifiable data, but the map in Figure 16 taken from Thorne *et al.* (2016) shows the prevalence of non-dairy cattle at an electoral division level across the country. It is undoubted that the suckler sector is prevalent, and that suckler farmers are located in almost every electoral division in Ireland.

Figure 16: Non-dairy Cattle as a Percentage of Total Electoral Division Livestock Units



Source: Thorne et al. (2016, p. 8).

In addition to generating employment and economic activity in rural areas, farm families by their very presence in such remote areas contribute to the social fabric of vibrant rural societies. Data collected by Teagasc for a European project, FLINT, showed that Irish farmers are active in numerous community and voluntary organisations in rural areas and often provide their farm facilities and resources for community events such as shows and fairs, (Poppe et al 2016). One example of farmers' tangible contribution to society is the *Kerry Social Farming Project* where farming families engage to facilitate social inclusion in the rural community with people who avail of on-going health and social support services provided by "social farming" (Kerry Public Participation Network, 2018). Crowley *et al.* (2017) reported the following benefits received by those participating in social farming:

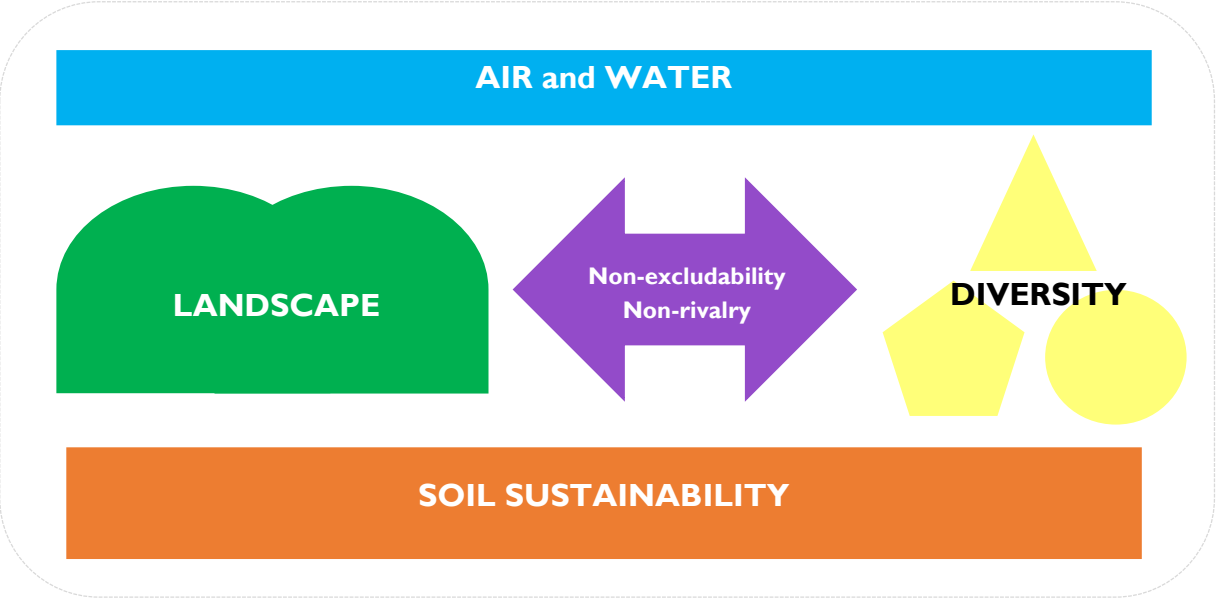
- Physical health: fresh air, being outdoor and active, enhanced sleep, improved motor skills.
- Mental health: calmness, confidence, enjoyment, therapy, independence, stimulation and meaningful activity.
- Educational: skills, learning, progression.
- Social: social inclusion, bigger social circle, friendship, community integration.

5.3 Public Goods

Agriculture is widely recognised to be multifunctional in the sense that it jointly produces multiple outputs - a range of marketable food and fibre outputs alongside environmental outputs, both positive, such as landscape amenities and biodiversity, and negative, such as nitrogen surpluses and other pollutants, as well as cultural outputs in terms of the maintenance of traditional farm practices, buildings and landscapes.

Public goods are goods (or services) that are not usually delivered through market mechanisms and are accessible to everyone to be enjoyed jointly (European Network for Rural Development, 2018). The key concept of public goods involves so-called 'non-excludability' and 'non-rivalry', which mean that if the public good is available to one person, others cannot be excluded from the benefits it confers, and if the good is used by one person this does not reduce the availability of that good to others. A classic example is a beautiful countryside that can be enjoyed by all. These particular attributes make it difficult for private markets to engage in supply because of the free-rider problem: consumers who do not pay for the good cannot be excluded from consumption.

Figure 17: The Concept of Public Goods



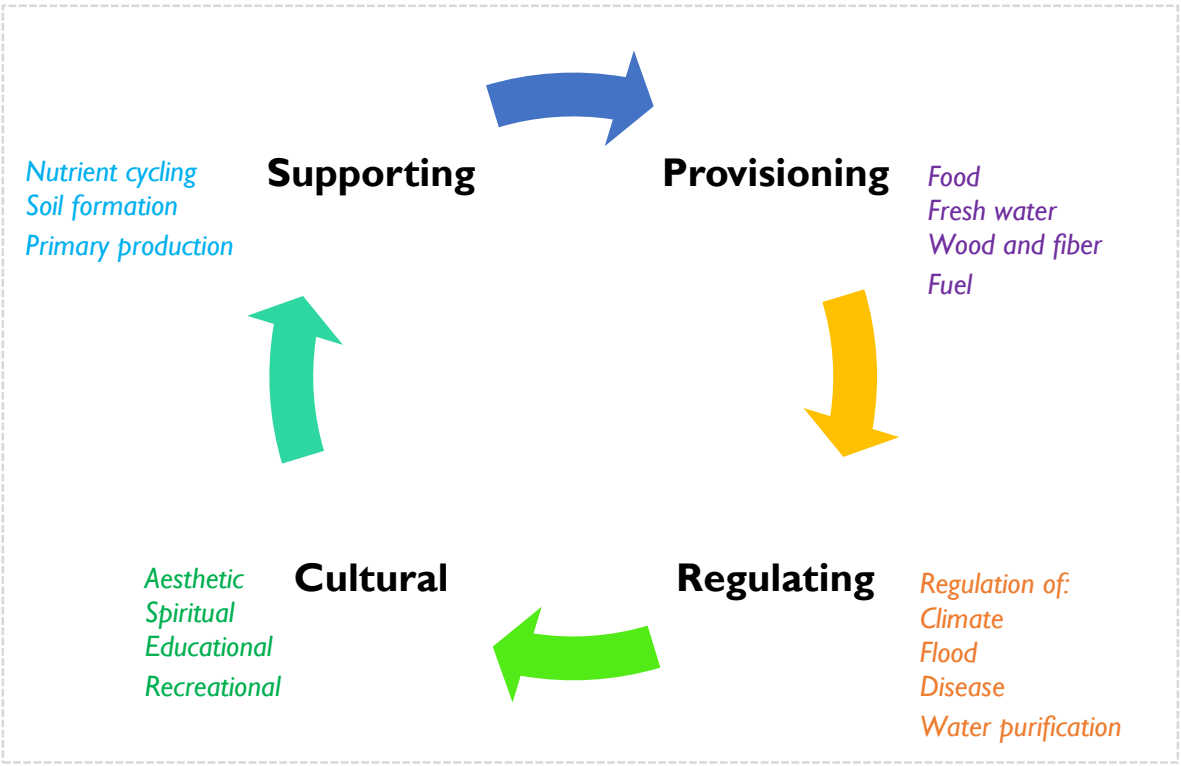
Source: Authors' illustration based on the literature review.

Public goods are not secured through markets because users have no incentive to pay for them, which in turn can lead to over-exploitation. On the other hand, land managers have little incentive to provide public goods such as those in Figure 17 as they are not paid for such goods. As a result, the undersupply of public goods and the absence of established markets constitute market failures, and as such require public intervention or policy support to ensure adequate provision. Since farmers control most land and production processes, public intervention is normally directed towards farmers to encourage the use of certain practices that divert from the exclusive production of farm commodities towards the joint production

of public goods such as nurturing landscape features and specific habitats or managing water resources (Cooper *et al.*, 2009).

Typical public goods provided through agriculture include: farmland biodiversity, landscapes, and natural resources such as water quality and availability, soil functionalities, climate stability (e.g. greenhouse emissions and carbon storage), air quality, resilience to flooding and fire, food security, rural vitality, preserving traditional heritage and culture and farm animal welfare and health (ENRD, 2018; Cooper *et al.*, 2009). Collectively these public goods are often referred to as ecosystem services, representing the benefits that humans gain from ecosystems and can be categorised in four main types: (i) provisioning services; (ii) regulating services; (iii) cultural services; and (iv) supporting services (see Figure 18). Provisioning services include food, water, raw material (e.g. organic matter, fodder and lumber), biogenic minerals, energy, genetic resources, medicinal resources (e.g. pharmaceuticals and chemical models) and ornamental resources (e.g. decoration and souvenirs like furs and orchids). Regulation services involve regulation of climate, floods, diseases, waste and water and air quality. Cultural services are reflected in the use of nature as a motif or symbol in books; folklore; architecture etc.; as a religious value; for recreation (including ecotourism); in science and education; and in therapeutic purposes. Finally, supporting services include nutrient recycling, soil formation and primary production, which enable ecosystems to provide water purification, flood regulation and food (World Resources Institute, 2005).

Figure 18: The Concept of Ecosystem Services



Source: Based on the Millennium Ecosystem Assessment, World Resources Institute (2005).

Clearly farmers have an important role to play in the production of public goods and ecosystem services. However, the type and system of farming is an important influence on the quantity and quality of public goods generated. Highly intensive indoor livestock systems produce very low rates of public goods while at the opposite end of the spectrum low-intensity grazing systems are the principal form of management of large areas of valued pastoral landscape and are critical to the maintenance of "High Nature Value" farmland in Europe (Baldock *et al*., 1993). Grazing systems such as suckler cow farming are often associated with high levels of public goods. Furthermore, cultural and archaeological heritage is often well preserved in extensive grassland systems because low stocking densities have resulted in relatively little structural change or soil disturbance. Hedgerows, field margins and drainage ditches along boundaries are often present in lowland beef systems, though perhaps at a lower density where the management is more intensive.

Active and appropriate management of the landscape is a key ecosystem service provided by farmers. Over or under-grazing of lands can negatively impact on biodiversity, that is the variety of plants and animals that are located in a habitat, on resilience to flooding and fires and the level of susceptibility to erosion by wind and water. Studies of the BurrenLife project, for example, have shown the key positive influences of appropriate grazing management on the preservation of this unique landscape and flora.

The difficult economic situation on many suckler farms coupled with the adverse production conditions in marginal areas, means that the risk of considerable de-stocking of animals and/or abandonment of land may be significant, and growing. Land abandonment is a serious concern for society as it can result in a change in the natural landscape, a loss of heritage features such as stone walls and native breeds of livestock, a loss of biodiversity, and a contraction of the rural population and communities.

5.4 Public Goods and Tourism

Even in areas where agriculture's contribution to the rural economy and employment is small, farming often continues to play an important social and cultural role. Culture and heritage can be typified by the physical features found in rural areas, and the traditional customs and practices that survive to this day. Many traditional customs, crafts, cuisine and music in rural parts of Europe are intrinsically linked to farming and agriculture, and as such farmers play a critical role in ensuring the future survival of such customs for all in society to enjoy, (Cooper *et al* 2009).

It is widely acknowledged that maintaining farmers on the land and supporting traditional farming practices is important for preserving heritage. The maintenance of stonewalls in the west of Ireland, farmhouses and working yards and traditional animal breeds are all examples of traditional agriculture that provides a unique identity and sense of place to a region (Figure 19). Such stonewalls mainly survive today because they continue to have a role in containing livestock but in doing so they continue to provide a link to past agricultural systems and important to local history.

Figure 19: Stonewalls - Link between Agriculture and Tourism

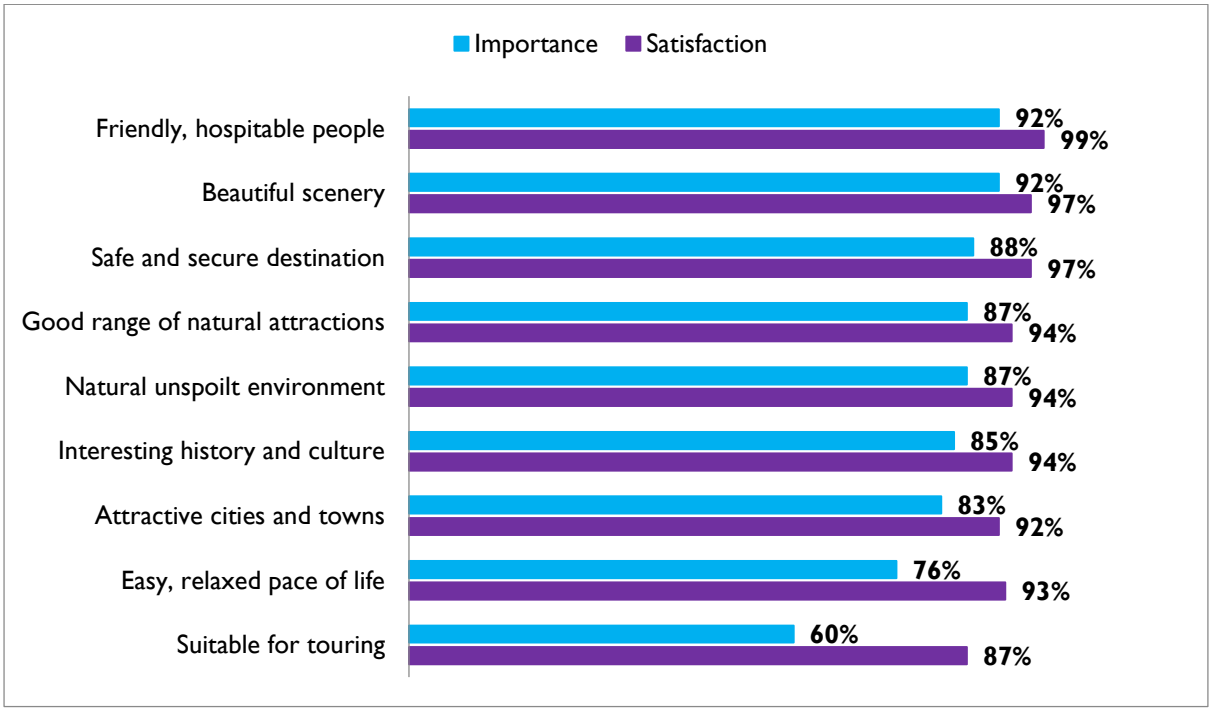


Source: Teagasc (2018).

The rural heritage and landscape that is protected by farmers is a key feature in attracting visitors to rural areas. The Irish tourism sector is an important contributor to national and regional economies. Combining the data from the domestic and international visitors, total tourism revenue for the economy in 2016 was around €7.8 billion, accounting for approximately 4 percent of Gross National Product. The tourism sector supports 148,300 jobs in the accommodation and food sector alone, and overall employment in tourism is estimated to be in the region of 220,000, Failte Ireland (2016).

Dublin is a large tourist market, accounting for 42 percent of international tourist spend, but regional tourism is also on the rise. Failte Ireland estimates that in 2016 18 percent of international tourist spend was in the South West, 12 percent in the West and 8 percent in the Mid West. Recent initiatives such as the Wild Atlantic Way have been hailed as a great success in attracting tourists to remote parts of Ireland and in boosting economic activity in these areas. Research by Deegan and Dineen (2003) has shown that rural tourism in Ireland is highly dependent on the quality of the natural environment, and images of a clean and green environment are ubiquitous in promotional materials. Clearly farmers play an important role in supporting rural tourism. Furthermore, a 2017 study of British tourists in Ireland revealed that visiting a rural area was the second most popular reason for visiting Ireland. For American tourists, "country walking" was the fourth most preferred holiday activity while in Ireland, along with visiting a festival celebrating local culture, food and heritage. The most recent survey by Fáilte Ireland (2018) showed that beautiful scenery scored high on the priority list for the holidaymakers when visiting Ireland, as did a natural unspoilt environment (Figure 20).

Figure 20: Importance and Satisfaction Levels with Specific Factors When Visiting Ireland, 2017



Source: Fáilte Ireland (2018).

Low-intensity farming, such as suckler cow farming, makes a positive impact on the aesthetics of the countryside and contribute to the success of rural tourism in Ireland. Across Europe, a number of studies have linked the provision of public goods by farmers to vibrant rural tourism. Of particular interest is the study by Vanslembrouck *et al.* (2005) who found that rural tourism is influenced by landscape features, and that extensive grazing systems, as opposed to other agricultural systems, has a positive impact on tourists' willingness to pay for rural accommodation.

5.4 Conclusions

In addition to its economic impact, suckler farming generates a non-economic benefit for wider society. Often located in marginal or economically disadvantaged areas, suckler farmers contribute to the social fabric and cultural capital of rural communities. They produce public goods such as protection of the environment, preservation of the landscape and unique features such as stonewalls, traditional farmhouses and hedgerows all of which positively contribute to the image of rural Ireland and rural tourism. The difficult economic situation of suckler farms may result in de-stocking or land abandonment causing a loss of natural landscape features, biodiversity and a contracting rural community.

Chapter 6: Environmental Sustainability of Irish Beef

6.1 Introduction

Stemming from environmental and health concerns, the concept of sustainable diets is gaining traction. A sustainable diet seeks to optimise health and nutritional considerations, affordability, and cultural acceptability, while minimising the negative environmental impact of the diet. A Eurobarometer survey conducted in 2014 revealed that almost all Europeans stated that the protection of the environment was important to them, and 85 percent of the respondents believed that they could play a role in its protection (Eurobarometer, 2014). In addition, about four-fifths of the respondents agreed that the efficient use of natural resources could boost economic growth, and six out of ten advocated environmentally friendly considerations over cost considerations when it came to public authority decisions about the environment (Eurobarometer, 2014).

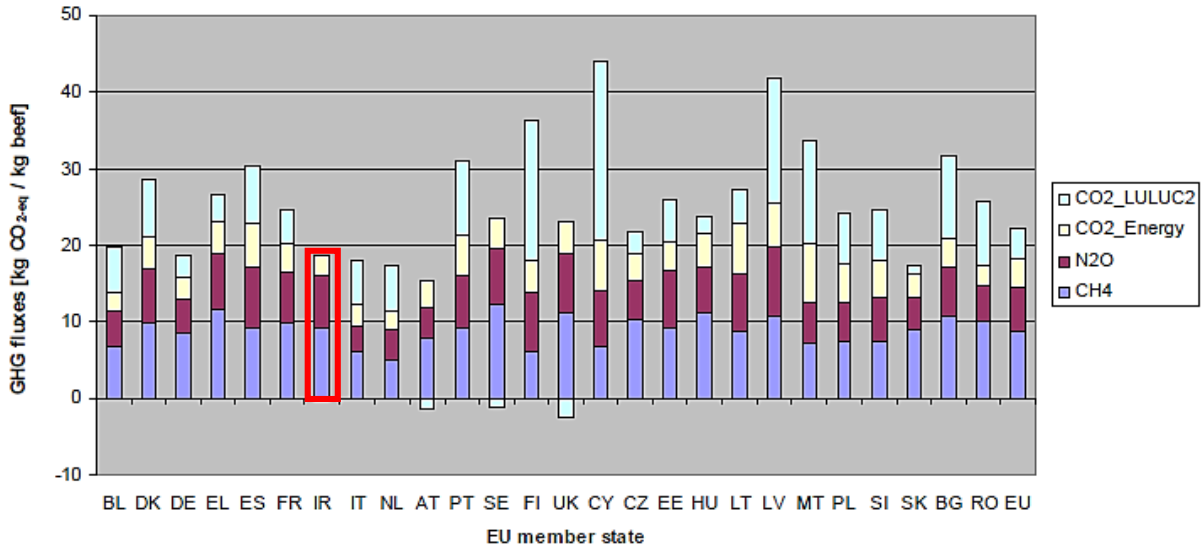
Many of the food attributes that sustainability-conscious consumers seek are embodied in Irish beef production, and as such the move to more sustainable diets may represent a major opportunity for Ireland's food industry in general and beef in particular. This chapter reviews the environmental performance of beef production in Ireland especially in relation to other key beef producing and exporting countries. The Irish beef carbon and water footprint are examined as well as the levels of nitrogen surpluses. The chapter concludes with an overview of the animal welfare performance of the Irish beef sector.

6.2 The Carbon Footprint of Beef Production

As discussed in Chapter 3, growing concerns about climate change and policy initiatives aimed at reducing agriculture's contribution to greenhouse gas emissions have drawn increased attention to the carbon footprint of food production globally. In this section, the carbon footprint of beef production in Ireland is compared to other key beef producing countries.

In a European context, the Irish beef sector can be considered quite carbon-efficient. A comprehensive assessment of the contribution of the European livestock sector to GHG emissions was conducted by the European Commission in 2010. The study evaluated the full net carbon emissions of a range of livestock products, taking account of all on-farm emissions related to livestock rearing and the production of animal feed (even where this feed production takes place outside the EU), as well as emissions caused by providing inputs of mineral fertilizers, pesticides, energy, and land for the production of feed. Figure 21 illustrates the carbon footprint of beef across various Member States. Ireland has the fifth lowest carbon footprint for beef production in Europe: only Italy, the Netherlands, Austria and Slovakia are more carbon-efficient. Irish beef has a carbon footprint of 19 kg CO2-eq/kg beef which is below the EU average of 22.1 kg CO2-eq/kg beef. Importantly, France and Germany, the EU's largest beef producers, producing over one-third of European beef between them, are less carbon-efficient than Irish beef production.

Figure 21: Carbon Equivalents per Kg of Beef: EU member states



Source: European Commission JRC (2010).

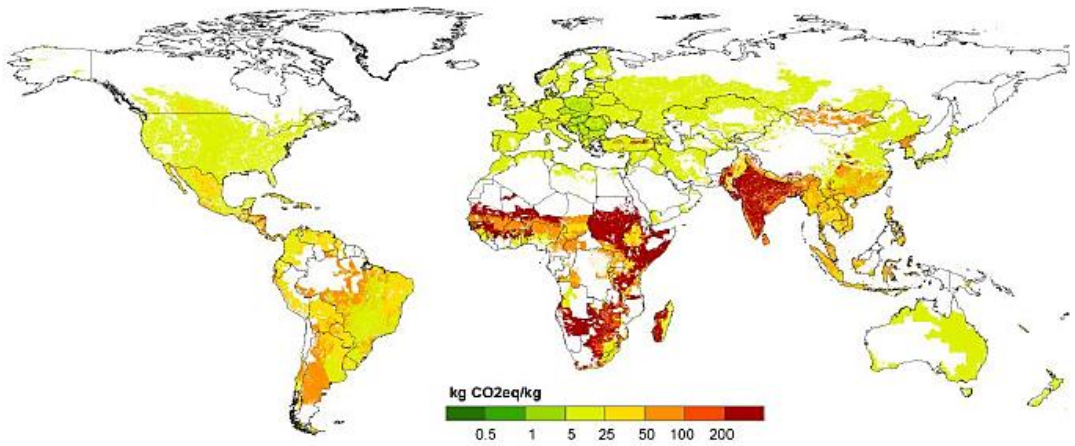
The Commission report also considered the carbon footprint of some imported foodstuffs, including Brazilian beef, whose carbon footprint was estimated to be 80 kg CO2-eq when land use change is included, over 4 times the Irish level (and 48 kg when land use change is not considered). Current climate change policy applies GHG limits at a national level. Thus, if Ireland were to reduce beef production to comply with a national limit, and Brazil increased production to fill Ireland's market share, global CO2 emissions would increase. This concept is referred to as carbon leakage.

Lanigan and Donnellan (2018) reported on recent analysis by Fellmann *et al.* (2018) which concluded that pro-rata reductions for EU agriculture to meet EU 2030 targets would result in significant leakage effects. Fellmann *et al.* (2018) argued for more flexibility in national versus global policies to limit GHGs, proposing multilateral commitments for agriculture to limit carbon leakage in addition to consumption side initiatives to tackle the reduction in GHG emissions.

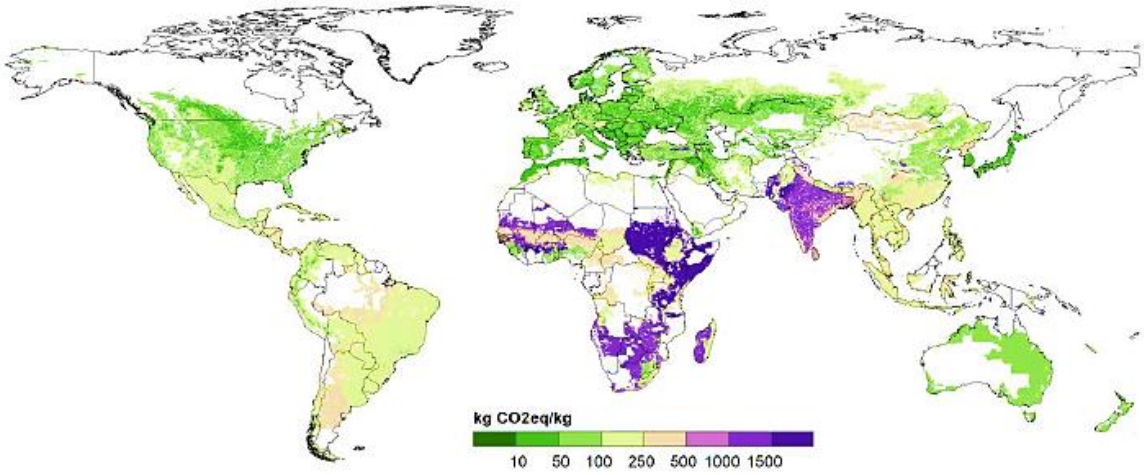
An overview of the global greenhouse gas efficiency of bovine meat production in 2000 produced by Herrero *et al.* (2013) showed that the US, South America and Europe had medium emissions, while some parts of Africa and India had very high emission levels - up to 200 kg CO_2 eq/kg product (Figure 22, part I). Similarly when examined using a CO_2 eq/kg protein metric, low emissions were recorded in the US and Europe, medium emissions in South America and high to very high emissions in parts of Africa and India (Figure 22, part II).

Figure 22: GHG Efficiency of Bovine Meat Production Expressed in kg CO_2 eq/kg Product (I) and Protein (II) in 2000

I



II



Source: Herrero et al. (2013).

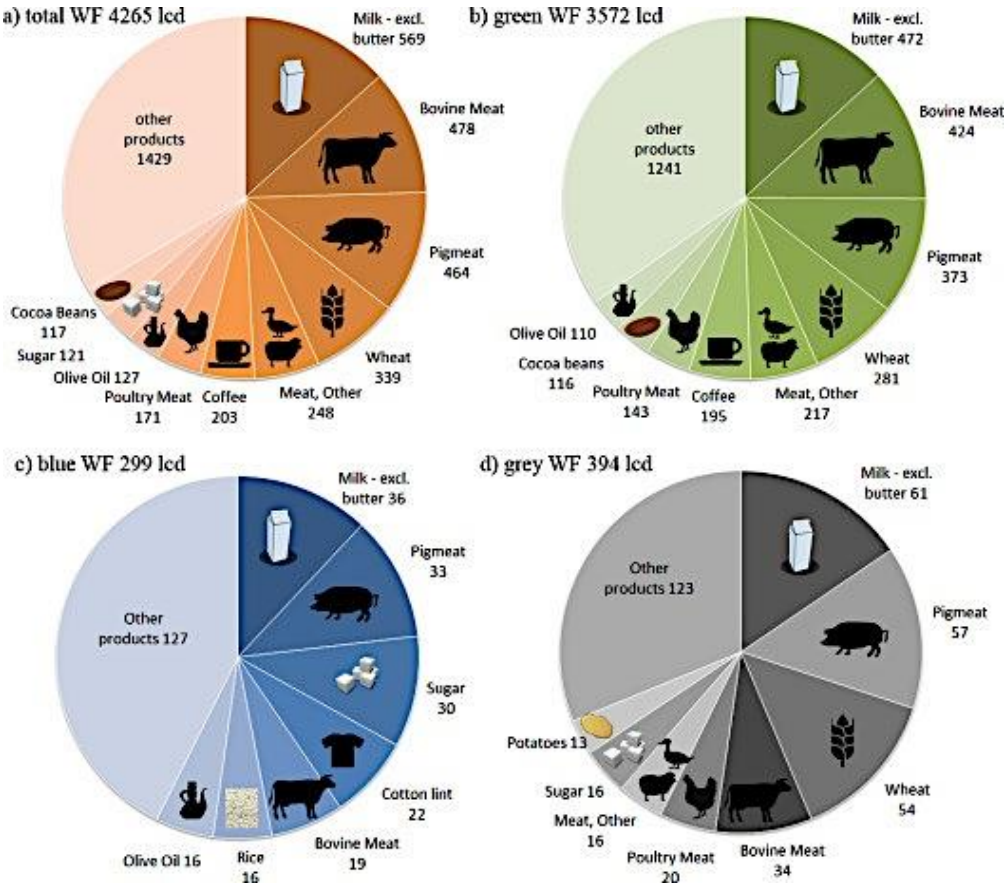
In collaboration with the Carbon Trust, Bord Bia recently introduced carbon footprint models to demonstrate the relative carbon efficiency of Irish agriculture (Carbon Trust, 2018). In addition, Bord Bia annually conducts sustainability audits of over 38,000 Irish beef farms, which are members of the Quality Assurance Scheme. The development and widespread adoption of the Teagasc Carbon Navigator, which is designed to measure the farm-level carbon footprint and identify means of reduction, is also a major development contributing to greater awareness of carbon efficient practices at the farm level.

To further promote and improve carbon-efficient beef production, the Irish Department of Agriculture, Food and the Marine launched the Beef Data and Genomics programme in 2015. The scheme is aimed at improving the genetic merit of the suckler herd with a view to reducing GHG emissions and improving profitability. The scheme works on the principle that increasing the genetic merit of the suckler herd through the €urostars programme, which is run by the Irish Cattle and Breeding Federation (ICBF), will result in more calves per cow per year and less greenhouse gases per livestock unit. Teagasc research has shown that compared to 1 star cows, 5 star cows are more profitable (+€136/parity), more sustainable (weanling efficiency), and more carbon-efficient (-550 kg CO2). There are approximately 24,000 farms enrolled in the BDGP programme, with over half a million cows on the participant farms. Participating farmers receive a payment equivalent to €95 for the first 10 cows in the herd, and €80 for each remaining cows, less the service charge of €22. It is estimated by ICBF that by 2030 the genetic gain achieved through the programme will reduce greenhouse gas emissions by 14 percent per kilogram of beef produced.

6.3 The Water Footprint of Beef Production

The future availability and quality of water sources is a key environmental concern globally, and one of the important Sustainable Development Goals. The UN estimates that, in less than 15 years from now, some two-thirds of the world's population could be living under water stress conditions. As such, water footprints, which represent the use of water resources in the consumption of goods, are coming under increased scrutiny. It is estimated that, on average, 80 percent of the fresh water withdrawn from rivers and groundwater globally is used to produce food and other agricultural products. The water footprint of livestock farming in particular is often the subject of criticism. For the EU28, the water footprint of consumption is a total volume of freshwater that is used to produce the goods consumed by its inhabitants (European Commission, 2016). A higher water footprint is associated with animal rather than crop based food products, especially meat (Figure 23) (European Commission, 2016). For example, the water footprint of meat from beef cattle is on average 15,400 m^3 per ton, which is considerably higher than the water footprint of meat from sheep (10,400 m^3/t), pigs (6,000 m^3/t), goats (5,500 m^3/t) or chickens (4,300 m^3/t) (Mekonnen and Hoekstra, 2010).

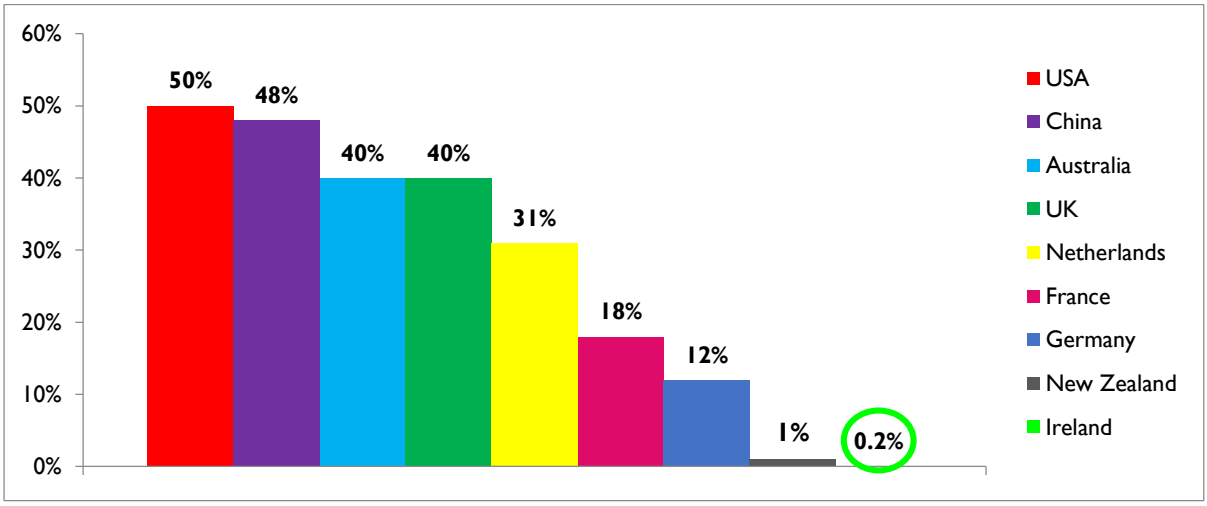
Figure 23: The EU28 Water Footprint (in lcd) for Different Products (1995-2005)



Source: Vanham et al. (2013).

The Irish climate means that Ireland has a low water footprint for food production, with most of the water used in production being "green", that is rainfall water rather than water abstracted from rivers. The UN placed Ireland as a top performer in food production with a 0.2 percent stress rating for water (Figure 24). A study by Teagasc (2017e) stated that the average stress-weighted water footprint of beef was 91 L H_20 eq/kg carcass weight, meaning that each kg of Irish beef produced is equal to consumption of 91 L of freshwater by an average world citizen.

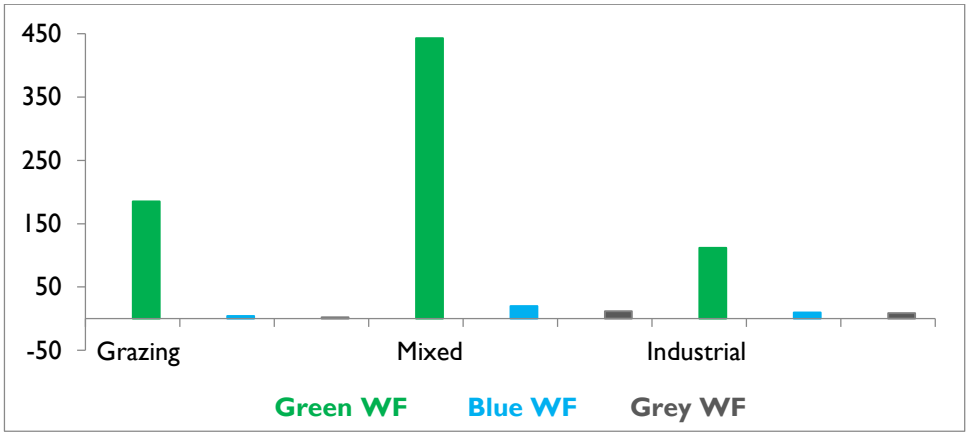
Figure 24: Global Water Stress Index for Food Production



Source: Bord Bia (2015, p. 46) based on UN analysis.

In terms of beef farming, grazing production systems showed the lowest levels of green, blue and grey water footprint when compared to mixed and industrial farming systems (Figure 25) (Mekonnen and Hoekstra, 2010). This represents a significant marketing opportunity for Irish beef farmers as over 80 percent of the beef is grass-fed (Bord Bia, 2017).

Figure 25: Green, Blue and Grey Water Footprints for Different Beef Production Systems (Gm^3/year)



Source: Based on Mekonnen and Hoekstra (2010).

Water consumption per kilogram of beef produced from suckler cows in Ireland is shown in Table 9. Intensive farm systems have lower water consumption per unit of output than the extensive ones because the higher water consumption per head is offset by high output (Hess *et al.*, 2012). The majority of the water consumed in both intensive and extensive systems is green water, which has negligible impacts on the environment and low opportunity cost as the rain water cannot be used as a substitute for domestic or industrial water (Hess *et al.*, 2012). On the other hand, blue water consumption is low for all systems.

Table 9: Total Water Consumption for Irish Beef Suckler Cows

(litres per kg edible carcase weight - live weight multiplied by killing out percentage)

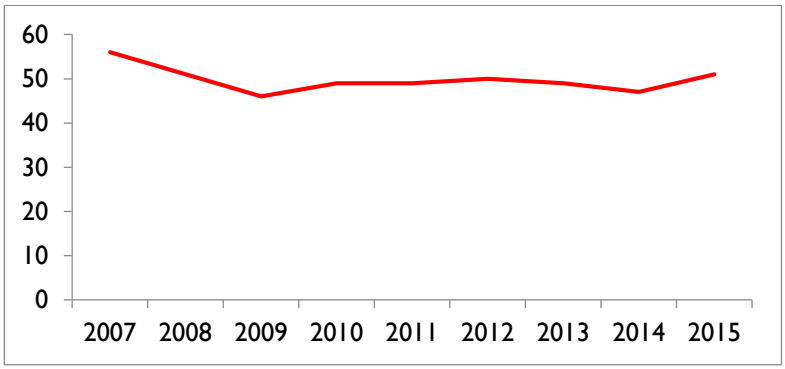
System	Calving	Finishing	Blue water	Green water	TOTAL
Beef suckler	Spring	Extensive	42.4	9,850	9,892
		Intensive	40.6	9,890	9,931
	Autumn	Extensive	50.7	10,700	10,751

Source: Hess et al. (2012).

6.4 Nitrogen Balance

The gross nutrient balance on agricultural land presents the total potential threat to the environment of nitrogen surplus or deficit in soils (Eurostat, 2018b). Lack of nitrogen can cause erosion and degradation in soil fertility, while nitrogen surplus can result in eutrophication and pollution of surface and ground water (Eurostat, 2018b). At the EU level, the trend in agricultural nitrogen balance improved from 2010 to 2014; however, in 2015 the nitrogen surplus increased again, affecting the nitrogen balance, which was estimated at 51 kg of nitrogen per ha (Figure 26).

Figure 26: Gross Nitrogen Balance at the European Union Level (kg N/ha), 2007-2015

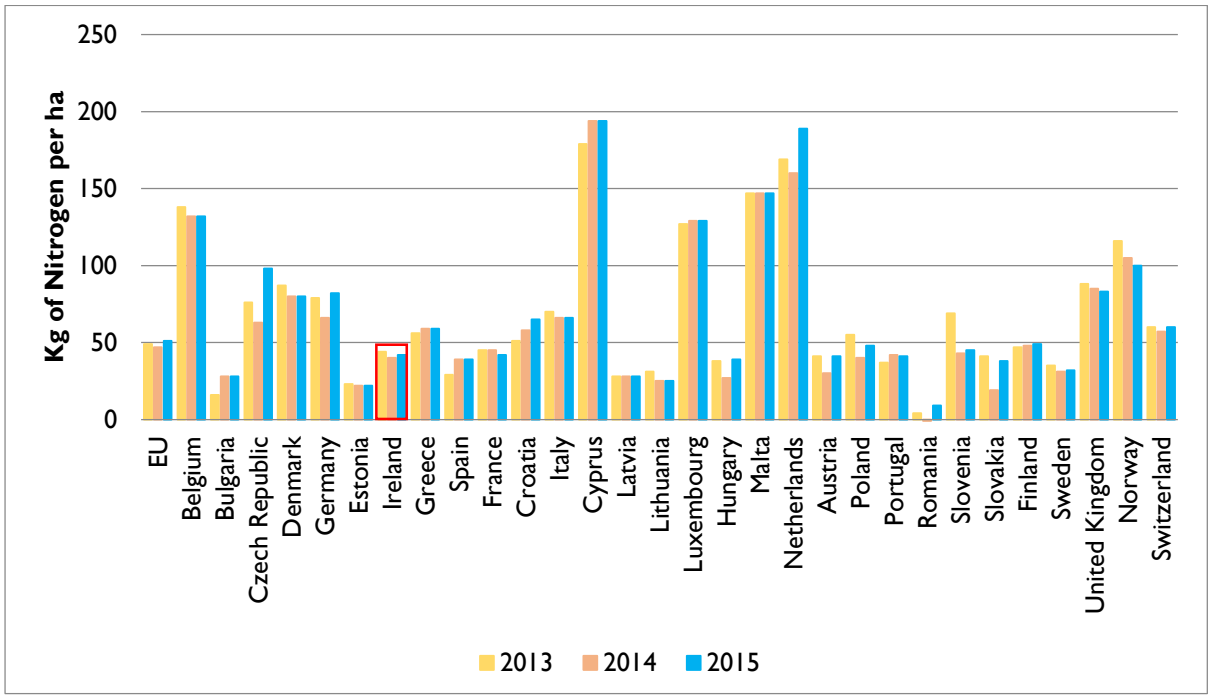


Source: Eurostat (2018c).

In Ireland, the nitrogen balance in 2015 was 42 kg per hectare, 9 kg lower than the EU average (Figure 27). Nitrogen input was estimated at 201 kg per hectare, while the nitrogen output reached approximately 158 kg per hectare. In addition, Ireland's nitrogen balance was more favourable than in Germany (82 kg in 2015) or the UK (83 kg in 2015), which are significant beef producers in the EU (Eurostat, 2018d). A study of nitrogen efficiency across European agriculture showed that livestock production in Ireland was the most nitrogen efficient in the EU (Leip *et al.* 2010). The study estimated the "nitrogen footprint" of livestock production in

Ireland to be 39.3 per kg of product compared to 64.7 for the EU average. The EU analysis was not conducted for beef specifically at a national level.

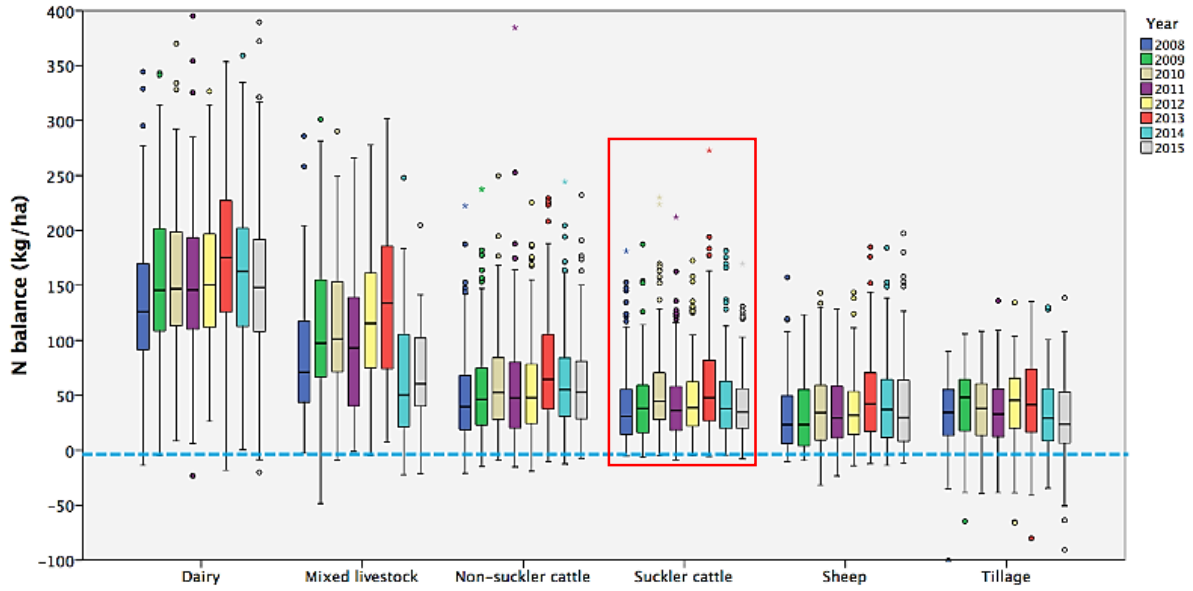
Figure 27: Gross Nitrogen Balance per Hectare of Utilised Agricultural Area in the EU, 2013-2015



Source: Eurostat (2018d).

Furthermore, Thomas *et al.* (2017) found that the nitrogen balance for suckler cattle in Ireland was more favourable than that for dairy, mixed livestock and non-suckler cattle (Figure 28). An average nitrogen balance for the period 2008-2015 on the suckler farms was 38.1 kg of nitrogen per hectare, considerably lower than for dairy farms (149.2 kg/ha), mixed livestock farms (96.8 kg/ha) and non-suckler farms (49.9 kg/ha) in the same period.

Figure 28: Nitrogen Balance for Different Farming Systems, 2008-2015



Source: Thomas et al. (2017).

6.5 Animal Welfare Performance of Irish Beef Production Relative to Beef Production Globally

Animal welfare legislation serves to protect all animals that interact with humans, and EU farmers are obliged to follow the general requirements from EU Directives as well as the legislation and codes of practice of their homeland (SafeFood, 2008). In Ireland, the Farm Animal Welfare Advisory Council has adopted best farm animal husbandry practices and welfare standards, which are established around the five basic needs:

- Freedom from thirst, hunger and malnutrition;
- Freedom from discomfort;
- Freedom from pain, injury and disease;
- Freedom to express normal patterns of behaviour; and
- Freedom from fear and distress (Farm Animal Welfare Advisory Council, 2003).

In addition, the Irish Animal Health and Welfare Act (2013) provides details on appropriate practices when dealing with animals. Table 10 summarises current guidelines on specific issues (e.g. disbudding, housing and transport) related to the welfare of the farm animals in Ireland and the US. The guidelines vary between the countries and across the certified programmes. For instance, while disbudding calves over 14 days without a local anaesthetic is illegal in Ireland, according to AWA it can be done up to two months of age without pain relief. When kept in groups, the unrestricted movement allowance available to each calf between 150 kg and 220 kg in Ireland is 1.7m^2, while to each calf between 100 kg and 200 kg in the US it is 2.5m^2 (AWA standards). Tail docking is prohibited in Ireland according to AWA and CHP standards.

Next page: **Table 10:** Comparison of the Animal Welfare Guidelines for Beef Production in Ireland and the US (Excerpt) ***Source: Based on FAWAC (2008), Animal Health and Welfare Act (2013), Animal Welfare Institute (2018a) and Woiwode (2011).*** *Note: AHC = American Humane Association, CHP = Certified Humane Programme, AWA = Animal Welfare Approved and GAP = Global Animal Partnership).*

Standard	Ireland	The US Certified Programmes
Stockmanship	• Specific stockmanship skills are a key factor in animal welfare and can be developed on-farm, working with experienced person or through a course. • The stockman should have training and/or necessary experience in cattle husbandry.	• Not addressed specifically.
Disbudding and dehorning	• Disbudding calves at a young age is less stressful than dehorning older animals. • It is illegal to disbud or dehorn calves over 14 days old without using a local anaesthetic. A veterinarian should only carry out dehorning in exceptional circumstances. • A cauterisation method is used at one-two weeks to remove the horn buds. • A custom-built calf-dehorning crate is used to minimise stress to the calf and for optimum safety to the operator.	• Approved disbudding methods include cautery paste and hot iron with pain relief (AHC & CHP). • Disbudding allowed up to 2 months of age, pain relief not required (AWA). • Disbudding must be performed before 6 weeks of age, pain relief required for use of hot iron (GAP). • Dehorning is prohibited (AWA). Horn removal after 30 days (AHC) or 2 months (CHP) must be done by vet with pain relief.
Tail docking	• Prohibited.	• Prohibited (AWA, CHP) or not specified (AHC & GAP).
Housing and Facilities	• Cattle are usually outdoors at pasture 7-8 month period each year. • All houses should be adequately ventilated allowing for an adequate supply of fresh air and allowing heat dissipation and preventing the build-up of carbon dioxide, ammonia or slurry gases. • Surfaces should be even and non/slip to avoid unnecessary underfoot conditions. Surfaces on which cattle walk should be designed, constructed and maintained to avoid discomfort, stress or injury to the animals. • The accommodation should contain sufficient source of natural or artificial light so as not to cause discomfort to the animals.	• Access to pasture not required; access to the outdoors not clear (AHC). • Beef cattle must have year- round access to the outdoors, but not to pasture (CHP). Variations in access to pasture depending on cattle classification (GAP). • Continuous outdoor access to pasture is required for all animals (AWA). • Feedlots allowed but windbreaks and sunshades required in some instances (AHC & CHP). • Confinement to feedlots is prohibited (AWA). • Feedlots allowed at certain terms (GAP).
Spatial Allowance	• Housed stock should have freedom of movement and ample floor space for lying, grooming and normal animal-to-animal interactions. • The width of any individual pen for a calf shall be at least equal to the height of the calf at the withers, measured in the standing position. The length shall be at least equal to the body length of the calf, measured from the tip of the nose to the caudal edge of the pin bone, multiplied by 1.1. • For calves kept in groups, the unrestricted space allowance available to each calf shall be at least equal to 1.5m^2 for each calf with a live weight of less than 150 kg, at least equal to 1.7m^2 for each calf with a live weight of 150 kg or more but less than 220 kg. • Escapes/creeps should be provided, if young calves are housed with adults, i.e. sucklers	• Allow unrestricted movement; 3x5ft up to 220 lbs; 14x18ft up to 600 lbs (AHC). • Isolation prohibited; kept in familiar groups (AWA). • Buildings must provide relief from thermal stress; range must allow access to features that allow relief during extreme temperatures (AHC & CHP). • Heat must be provided as necessary (AWA). • Stock must be protected from heat or cold stress (GAP). • Ammonia <25 ppm (AHC & CHP) or <5 ppm detectable level (AWA).
Transport	• The transportation of exceeding eight hours is not permitted unless they are accompanied by their mother.	• In the shortest time possible, with no specific time limit given (AHC & CHP). • Transport must not exceed 8 hours (AWA). Different limits (GAP).

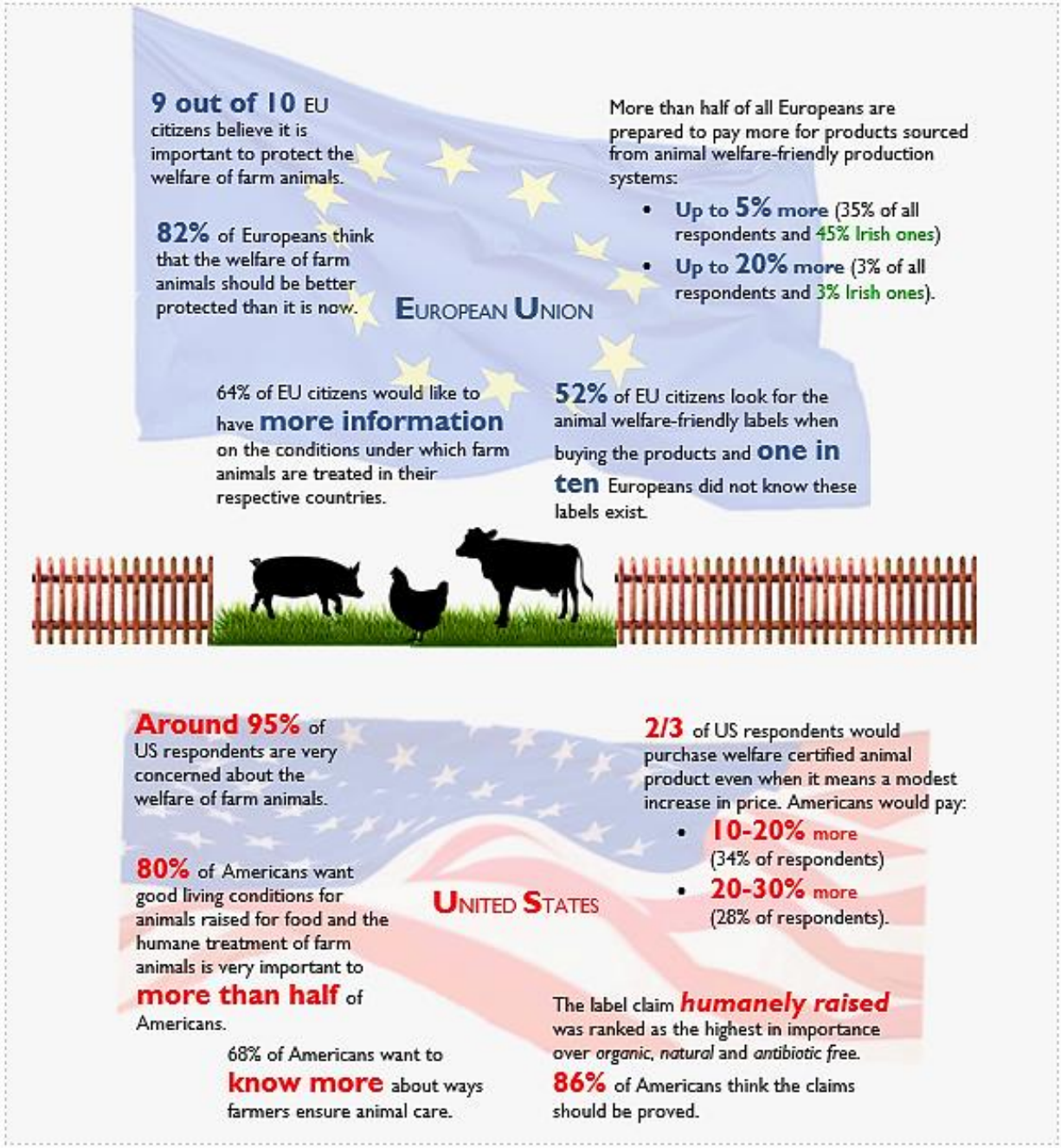
In Ireland, cattle are usually outdoors at pasture 7-8 months per year, which is considered as one of the advantages for the premium quality of Irish beef. American standards are not clear when it comes to access to pasture, ranging from: (i) no access required (AHC); (ii) access to outdoors but not the pasture required (CHP); (iii) or continuous access to pasture (AWA).

Animal welfare remains an important issue for many citizens of the EU (see Figure 29). A Eurobarometer survey published in March 2016 showed that an absolute majority of Europeans (94 percent) are of the view that it is important to protect the welfare of farmed animals. Almost two thirds of Europeans (64 percent) indicated that they would like to have more information about the conditions under which farmed animals are treated in their country, and 59 percent of EU citizens mentioned that they would be prepared to pay more for products sourced from animal welfare-friendly production systems. The opinions of the US consumers on the welfare of farm animals are similar to European consumers (see Figure 28). Americans want good living conditions for farm animals (80 percent), demand to know more about how farmers ensure animal care (68 percent), and are willing to pay more for the welfare-certified animal products (66 percent).

When questioned about animal welfare standards in the EU and the rest of the world, nine out of ten European respondents (90 percent) agree that it is important to establish animal welfare standards that are recognised across the world, and a larger number again, 93 percent, strongly agree that imported products from outside the EU should respect the same animal welfare standards as those applied in the EU.

To investigate animal welfare performance in Irish beef production, Mazurek *et al.* (2010) conducted an on-farm study of beef suckler herds using an animal welfare index (AWI). The authors assessed 194 beef suckler farms throughout 13 counties, and found that the mean AWI was 65 percent, with a range of 54 to 83 percent (Mazurek *et al*., 2010). In the study, 70 percent of the farms were rated as 'Very Good' or 'Excellent', which is relevant considering that improving animal welfare is an important factor in livestock production due to increased consumers' concern about the source of animal products and practices related to animal husbandry (Mazurek *et al*, 2010). In 2011, the DAFM assessed the animal welfare scheme for suckler herds and concluded that it had a positive impact in bringing a long-term change to welfare practices (DAFM, 2011). It found that the animal welfare measures directly contributed to improved prices for weanlings and also improved the reputation for Irish beef and live exports in key markets. Most importantly, the measures encouraged significant attitudinal and behavioural change by suckler farmers, which is hoped to result in continuous implementation of animal welfare practices even in the absence of a scheme (DAFM, 2011).

Figure 29: Consumers' Perceptions of Animal Welfare in the EU and US



Source: Based on Eurobarometer (2016) and Animal Welfare Institute (2018b).

In terms of the use of hormones in beef production, EU Directive 96/22/EEC prohibited the use of substances, e.g. testosterone, progesterone, zeranol, oestradiol 17ß and others, that have a hormonal action enhancing the growth in farm animals. This Directive applied to all EU Member States and also to imports from third countries. The European Parliament and Council revised the Directive in 2003, and amended the rules applying to the use in stock farming of certain substances with drastically reduced circumstances under which oestradiol 17ß can be administered for other purposes to food-producing animals. This Directive, however, is not compatible with the U.S. Food and Drug Administration (FDA) law, according to which a number of steroid hormone drugs and implants, including natural estrogen, progesterone, testosterone and their synthetic versions, are approved in beef cattle production (FDA, 2017). These drugs are available for over-the-counter purchase but are not allowed for growth purposes in dairy cows, veal calves, pigs or poultry.

Under the EU legislation, each member country has to implement and submit the results of a residue monitoring plan on a yearly basis for the approval of the European Commission. The latest results of Irish National Residue Plan in 2016 showed a high level of compliance with the EU Directive. The overall level of non-compliance was only 0.2 percent, which means that just 40 out of 19,250 samples were non-compliant (DAFM, 2017). This high level of compliance has been consistent over the last few years, and demonstrates the responsible approach to food production that the vast majority of Irish farmers adopted (DAFM, 2017).

In recent times, there have been a number of scandals about animal welfare, production and food safety standards of the some of the Mercosur countries, Brazil in particular. In March 2017, news broke of a major bribery and corruption case in Brazil. "Operation Weak Flesh," as it was named by Brazil's federal police, involved allegations of bribery by two major exporting companies. Police accused more than 100 workers of taking bribes in exchange for clearing rancid meat for export with all the necessary paperwork. In May 2017, an EU Food and Veterinary Office (FVO) report concluded that competent authorities in Brazil were signing export report certificates despite being unable to ascertain the veracity of certain statements therein, and went on to pronounce that the Brazilian Competent Authority was not in a position to guarantee that the relevant export requirements were met. In June 2017, the U.S. Department of Agriculture suspended imports of all fresh beef from Brazil because of recurring food safety problems.

6.6 Perspectives on the Quality of Irish Beef

Moloney and Allen (2016) note that almost 90 percent of the beef produced in Ireland is exported into highly competitive markets, and this is evidence that its quality compares favourably with beef from other sources. They note that the unique selling points of Irish beef include the "green" image of Ireland, the grass-fed production system which gives the meat a distinctive flavour and a more healthy fatty acid profile than the concentrate-based diets common in continental Europe and the US. Most Irish beef is from steers and heifers compared to beef from cows and young bulls, which is common in many European countries, and would generally be of inferior eating quality. Grass-fed cattle roam free on pastures, while grain-fed cattle are often confined in feed lots. However, the most significant difference between the two systems is in the finishing stage where grass-fed cattle remain on the pasture

and are finished on a diet that is mostly grass or other forages. Grass-fed beef tends to have lower fat than grain-fed beef. In addition, grass-fed beef has two to six times more omega-3 fatty acids, is a rich source of conjugated linoleic acid (CLA), and does not contain artifical hormones.

Grass-fed beef is increasingly commanding a price premium on markets in developed and affluent countries. Fresh grass-fed beef commanded a 71 percent premium over conventional beef (net of discounts) at the US retail level in 2016 (Stone Barns Center for Food and Agriculture, 2017). Market research has shown that from a consumer's point of view, grass-fed beef has three major potential benefits: health and nutrition (Duckett *et al.*, 1993), animal welfare (Morrow-Tesch 2000), and ecosystem-friendly farming practices (Horrigan *et al.*, 2002). According to Nielsen (2017), US and Canadian consumers are willing to pay more for meat that is ethically raised (31 percent US, 35 percent Canada) and clearly labelled with transparent claims such as 'antibiotic-free' (27 percent US) and 'grass-fed' (17 percent US). In 2016, sales of grass-fed beef in the US reached €272 million (Bord Bia, 2018d). The increased US demand for grass-fed beef represents a great opportunity for the Irish beef sector as Ireland has first-mover advantage due to the fact that it is the first EU country to re-gain entry to the US market (Department of Foreign Affairs and Trade, 2015).

6.7 Conclusions

Consumers are becoming increasingly concerned about the environmental sustainability of food production, and Ireland produces some of the world's most environmentally sustainable beef. The carbon footprint of beef production in Ireland is the fifth lowest in Europe, and almost one-quarter of the Brazilian footprint. However, if Ireland reduces beef production to meet GHG commitments, then carbon leakage is a major concern as less carbon-efficient countries may increase beef production to satisfy growing consumer demand globally. Ireland is a highly water-efficient producer of food, with a 0.2 percent stress rating, and international studies have also shown that Ireland is the most nitrogen-efficient producer of livestock products in Europe. Modern consumers demand transparency and increasingly care about the source of the animal products and the welfare of farm animals. Animal welfare standards in Ireland are high, and in accordance with the European Union requirements. In addition, over 80 percent of Irish beef is grass-fed, which translates into better conditions for the animals and meat that is lower in fat but high in omega-3 fatty acids.

Chapter 7: The Economic Impact of a Potential Contraction in the Suckler Cow Herd

7.1 Introduction

Brexit, the future of the Common Agricultural Policy, and climate change policy all pose threats to the future development of the beef sector in Ireland. If not handled proactively, these challenges could lead to a reduction in direct payments and/or beef prices, and in turn to a contraction in the national suckler cow herd. This chapter explores the economic impact of a number of potential negative shocks to the suckler cow herd.

7.2 The Economic Impact of a Contraction in the Suckler Cow Herd

This analysis assumes a shock to the beef sector arising from one of a number of policy and market related challenges on the horizon. According to the CSO the value of beef output generated by the primary agricultural sector was approximately €2.36 billion in 2017, this includes beef meat arising from dairy and beef breed animals. Official data are not available on the output generated by the suckler herd, instead it is estimated here that approximately 60 percent of total beef output comes from the suckler herd and its progeny. This estimate is based on suckler cows comprising 44 percent of all cows nationally and the progeny of suckler cows being more valuable than dairy cows as discussed in Chapter 2. This results in an assumed national output for the suckler herd of €1.45 billion.

The multiplier and employment coefficients presented previously are used to approximate the economic impact of shocks on output and employment. Technical Appendix 1 details the process used to obtain these hypothetical impacts. It is important to note that this analysis is static in that it assumes the suckler herd contracts and that there is no further adjustment to this shock. As noted above the output multiplier for the beef sector is calculated to be approximately 2.11. If we assume that this multiplier holds for the disaggregated sucker sector Table 11 provides a summary of the impact of a series of shocks to the suckler herd on the national economy. We assume three different levels of shocks to the suckler heard; 5, 10 and 20 percent.

To give an illustrative example, consider the impact of a 5 percent reduction in output. Total output for the suckler herd is €1.45b. A 5 percent reduction in this would be €0.0725b. However, given the multiplier of 2.11 this would have an indirect effect on related and interconnected sectors resulting in a total drop in national output of approximately €0.153b. This analysis is also conducted for a shock of 10 percent and 20 percent.

Table 11: Shock Analysis for the Suckler Herd

Shock to suckler herd	Output pre-shock (billion €)	Impact of Shock on suckler herd (billion €)	Multiplier for beef sector	Impact of shock on Economy (direct and indirect effects) billions €
5%	1.45	0.0725	2.11	0.152975
10%	1.45	0.145	2.11	0.30595
20%	1.45	0.29	2.11	0.6119

Source: Authors' work.

7.3 Agriculture Resilience - Can the Sector Resist and Recover from Shocks?

The importance of the agriculture, forestry and fishing sector can also be considered in terms of the stability of employment that it offers. The concept of economic resilience describes how resistant a region or a sector is to a shock and how well placed it is to recover following the shock. In light of the 2008 economic crisis, the resistance and recovery of agriculture to the crisis can be analysed using the framework provided by Martin *et al.* (2016). Table 12 provides the national resistance and recovery indices for Ireland by broad NACE sector. Technical Appendix 2 provides details on how these indices were calculated. A negative value means that a sector performed poorly compared to the national average, either during the resistance phase of the crisis 2008-2012 or the recovery phase of the crisis 2012-2016. The agriculture, forestry and fishing sector did not resist the crisis well compared to other sectors, but it exhibited the strongest recovery compared to the other sectors.

Table 12: National Resilience and Recovery Indices for Ireland

Sector	Resistance	Recovery
Agriculture, forestry and fishing	-1.06	2.72
Industry	-0.13	-0.39
Construction	-2.98	1.61
Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.01	-0.66
Transportation and storage	0.68	-0.54
Accommodation and food service activities	0.26	1.50
Information and communication	1.58	0.02
Financial, insurance and real estate activities	0.76	-1.37
Professional, scientific and technical activities	0.18	1.51
Administrative and support service activities	-0.66	-0.15
Public administration and defence, compulsory social security	0.75	-1.05
Education	1.33	-0.46
Human health and social work activities	1.53	-0.32
Other NACE activities	1.01	-0.51

Source: Authors' work.

These indicators can be broken down at a regional level: see Table 13. There is significant variation in the regional ability to resist the crisis and recover following the crisis. The Mid-East and South-West had the poorest resistance to the crisis while the South-West and Border region recovered strongly afterwards.

Table 13: Resistance and Recovery indices for Agriculture, Forestry and Fishing Sector by Region

NUTS3 Region	Res	Rec
Border	-0.40	4.03
Midlands	-0.77	2.85
West	-1.28	1.73
Dublin	-0.03	0.05
Mid-East	-2.16	1.92
Mid-West	-1.14	1.12
South-East	-0.51	0.15
South-West	-1.64	7.21

Source: Authors' calculations based on CSO QNHS data. Various years are used.

7.4 The Potential for Dairy Beef to Displace Suckler Beef

It is expected that the dairy sector will continue to grow, and as such an increasing share of the output of the beef sector will be comprised of dairy-bred beef. Some believe that the threat of a contracting suckler cow herd can be offset by the potential to replace this sector with dairy-bred beef. However, for others there are concerns about whether rearing dairy calves is an appropriate substitute for suckler farming. Single suckling selling weanlings is the most common production system in the west of Ireland. Typically, calves remain grazing with the cow and are sold once weaned. These calves are typically purchased by farmers with better production conditions and possibly based in a better climate, and are then fattened. Single suckling selling weanling farms may not have the land type, housing facilities and/or husbandry skills to finish dairy animals. Anecdotal evidence suggests that, despite a number of campaigns to promote dairy calf rearing in the west of Ireland, uptake has been very slow. It remains to be seen whether dairy beef can be a viable alternative to suckler farming in marginal areas.

7.5 Conclusions

The economic impact of the beef sector is significant and geographically dispersed. Any contraction in the suckler cow herd will lead to negative economic and employment impacts. It is estimated that a 5 percent contraction of the output of the Irish suckler herd would lead to a loss of €0.152 billion of output in the national economy. This negative impact would be

more apparent in sectors dependent on agriculture. Regarding the ability of the sector to recover after shocks, based on evidence after the general 2008 economic crisis, the agriculture, forestry and fishing sector is less resistant to shocks than other sectors but has a strong ability to recover following a shock. This positive ability to recover suggests the potential for the sector to bounce back following an external shock. However, this varies significantly across regions. For instance agriculture, forestry and fishing sector in the border regions showed strong ability to resist and recover following the 2008 economic crisis while a region such as the South-West was very negatively affected by the shock but subsequently recovered strongly. This suggests that across different regions the impact of any shock is likely to be felt to varying degrees.

Chapter 8: Conclusions

In this final chapter a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis is used to summarise the key findings of this report and put the current state of the Irish beef sector, and the suckler sector in particular, into context. SWOT analysis is a strategic planning technique used to assess the internal and external factors that impact a sector and could potentially determine the success of that sector in a short to mid-term period. It provides an insight into the sector's most prosperous and vulnerable parts, and enables informed decision-making for important strategic steps. SWOT analysis includes factors shaping the internal and external environment. The internal Strength and Weakness factors are controllable, while the Opportunity and Threat factors in the external areas are related to, for example, the state economy, global supply and demand and competition, and thus cannot be controlled.

As seen in Figure 30, the Irish suckler sector has a number of major strengths, including the size of the sector and its importance in terms of the other sectors it supports, job creation (directly and indirectly) and generating foreign earnings. The very high sustainability status of Irish beef is a major strength. Consumers' increasing awareness of sustainability issues, coupled with growing global demand for beef and more liberalised trade, are all strengths that will allow Ireland to capitalise on its image of clean, green, grass-fed beef.

Despite the economic significance of the suckler cow sector, the grave and difficult economic situation at the farm level is a major weakness. The very low market prices relative to production costs mean that this large farm sector is almost entirely reliant on direct payments. This obviously makes the sector, and indeed the entire supply chain, extremely vulnerable in light of the proposed cuts to the CAP budget. Any negative price shocks arising from threats such as Brexit or international trade deals will exacerbate the economic situation at the farm level making farmers even more reliant on payments. Climate change policy also remains a major threat for the future beef sector. Despite the very positive carbon performance by Irish beef farms, the absolute levels of emissions from agriculture remains a problem.

Figure 30: SWOT Analysis of the Irish Beef Sector



Source: Authors' work based on findings of the report.

It is clear that the Irish suckler cow sector is at a critical juncture. A number of factors threaten its future development. Without positive action, it is most likely that these factors will lead to a contracting suckler cow herd. Any further contraction in national suckler cow numbers will have implications for the large farming community, the vibrancy of rural areas, the agri-input sector, employment in the beef processing sector and the value of exports from Ireland and net foreign earnings. These negative implications will be most harshly felt in the west of Ireland and particularly in local economies and communities where there may be limited other opportunities.

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Appendices

Technical Appendix 1: Regionalisation of Multipliers

Multipliers are derived from input-output tables, which essentially present money flows to and from businesses, households and governments within a national or regional economy. Following Carey and Johnson (2017), if we assume n business sectors, we can represent input output tables mathematically as:

$$(\boldsymbol{I} - \boldsymbol{A})\boldsymbol{x} = \boldsymbol{f}$$

And if we solve for x we are left with:

$$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{f}$$

Where we can define each of the components as follows:

- x is a vector of gross output
- A is an n*n input-output coefficient matrix
- I is the identity matrix (1 on the diagonal and 0 elsewhere)
- $(I - A)^{-1}$ is the 'Leontief' inverse of a n*n square matrix
- f is a vector of final demand

The Leontief inverse $(I - A)^{-1}$ shows the change in output in each sector due to a unit change in final demand: this is the multiplier effects. The direct multipliers show the impact of a change in demand in sector n on output in sector n. The indirect multipliers show the impact of a change in demand in sector n on output in all other sectors. The total multiplier is the sum of the direct and indirect multiplier.

Normally these multipliers are calculated at a national level due to input-output tables being provided only at that national level. However, it is possible to provide approximations of regional multipliers, using one of a series of alternative techniques. FOr this study, we followed the non-survey statistical approach detailed by Kronenberg (2009) on the use of 'simple' location quotients (LQs) to regionalise multipliers. Carey and Johnson (2017) note that the different developments of the LQ approach do not provide an advance on the traditional simple LQ approach.

The LQ approach assumes that each regional input-output coefficient is related to its national counterpart in the following way:

$$\boldsymbol{a_{i,j}^R = t_{i,j} a_{i,j}^N}$$

Where $a_{i,j}^R$ is the regional input-output coefficients, $a_{i,j}^N$ is the national input-output coefficient, and $t_{i,j}$ is referred to as the 'trading coefficient'. There are various ways of estimating $t_{i,j}$ and the simple LQ method does so by calculating a LQ for each industry *i* and using it to proxy for $t_{i,j}$. We define the LQ as:

$$\boldsymbol{LQ_i = \frac{L_i^R / L^R}{L_i^N / L^N}}$$

Where each term is defined as follows:

- L_i^R is employment in region R in sector *i*
- L^R is employment in region R
- L_i^N is employment in the nation in sector *i*
- L^N is employment in the nation

As noted by Kronenberg (2009), "[a]ssuming equal labor productivity, LQ_i indicates whether industry *i* is "overrepresented" or "underrepresented" within a region. If the LQ is less than one then it is assumed that local production is not sufficient to supply local demand, which implies that within the region no exports are possible and imports are needed. In this instance the LQ_i value is substituted for the $t_{i,j}$. However, if the LQ_i term is greater than one this implies excess supply within a region and the region can export some of the supply from industry *i*. In this case we assume that $t_{i,j}$ is equal to one. In this way we can generate a matrix containing the regional input-output coefficients, given as *A*. The end result is the possibility to derive regional multipliers based on estimates of regional input output coefficients using employment to disaggregate these regionally.

Technical Appendix 2: Calculation of Resilience Indicators

We focus on two elements of resilience; resistance and recovery, relying on Martin *et al.* (2016), Martin (2010) and Palaskas *et al.* (2015). Resistance is the ability of a regional economy to resist the initial impact of the crisis while recovery is the ability to recover following the shock (Han and Goetz, 2013). Following, broadly, Han and Goetz (2013) and Martin *et al.* (2016), our indices for resistance and recovery are given by equations (1) and (2) respectively.

$$\boldsymbol{Resis_i} = \frac{(\Delta \mathbf{y}_i^c) - (\Delta \hat{\mathbf{y}}_i^c)}{\mathbf{E}_i^{2006}} \qquad (1)$$

$$\boldsymbol{Recov_i} = \frac{(\Delta \mathbf{y}_i^r) - (\Delta \hat{\mathbf{y}}_i^r)}{\mathbf{E}_i^{2006}} \qquad (2)$$

In (1), Δy_i^c is the change in employment in region *i* during the contraction period of the economic crisis, and in (2) Δy_i^r is employment change in region *i* during the post-crisis recovery period. In contrast to these actual employment changes, $\Delta \hat{y}_i^c$ is the expected counterfactual employment change during contraction, and $\Delta \hat{y}_i^r$ is the counterfactual change during recovery. For both resistance and recovery, the difference between actual and expected employment change over the periods of contraction, 2006-2011, and recovery, 2011-2016, are scaled by the level of employment in 2006. For both indices, a zero value indicates that a region's employment changed in line with the counterfactual (based on the national change), a negative value shows relatively weak resistance/recovery, and a positive value indicates stronger resistance/recovery relative to the national performance.

Technical Appendix 3: Biosector and Non-biosector Industries

In Riordan (2008), the following industries are considered:

A) Biosector

- Agriculture
- Forestry
- Fishing
- Food and beverages
- Tobacco

B) Non-biosector

- Mining and quarrying
- Textiles
- Wearing apparel
- Leather and leather products
- Wood and wood products (excluding furniture)
- Pulp, paper and paper products
- Printed matter and recorded media
- Petroleum and other fuels
- Chemical products and man-made fibres (including pharmaceuticals)
- Rubber and plastics
- Other non-metallic mineral products
- Basic metals
- Fabricated metal products
- Machinery and equipment n.e.c.
- Office machinery and computers
- Electrical machinery and apparatus n.e.c.
- Radio, television and communications apparatus
- Medical, precision and optical instruments
- Motor vehicles and trailers
- Other transport equipment
- Other manufactures
- Recycling