

# **Cows eat grass, don't they? Contrasting sociotechnical imaginaries of the role of grazing in the UK and Irish dairy sectors<sup>1</sup>**

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## **Abstract**

The role of grazing in dairy farming has become increasingly contentious. Dairy farming is still widely identified with imagery of cows grazing on grass, but grazing is a declining practice in Europe. The UK and Ireland make for interesting case studies to explore the politics of grazing as both countries are seen to have suitable conditions for supporting grazing but their dairy systems are very different. This paper explores the sociotechnical imaginaries of a high welfare, environmentally sustainable and economically viable dairy farming in the UK and Ireland, as described by key industry, academic, non-governmental organisation and government stakeholders in both countries.

Document analysis and interviews with key UK and Irish stakeholders revealed different sociotechnical imaginaries within and between countries. The dominant imaginary in Ireland was of a unified low cost grass based production system seen as high welfare because animals have access to pasture and inherently natural and environmentally sustainable. The dominant sociotechnical imaginary in the UK by contrast is that no system is better, but the success of a system depends on quality management and stock keeping.

The paper shows how the sociotechnical imaginaries are co-created by policy, market conditions and commitments to particular conceptions of economic viability, high welfare and sustainability. The different sociotechnical imaginaries can also be seen to pose a challenge to the other to the extent that science is held up as producing objective and value free truths about the best form of dairy production.

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## 1. Introduction

The role of grazing in dairy farming has become increasingly contentious and political. Dairy farming is still widely identified with imagery of cows grazing on grass but grazing is a declining practice in Europe (Reijs et al., 2013). Dairy farm systems in Europe are positioned between the high input-high output systems of pig and poultry which can operate without a surrounding land base, and the more extensive grazing beef and sheep systems which are dependent on a grazing land base. It is a time of change within the dairy industry involving restructuring and expansion after the removal of milk quotas in 2015. There are heated public and industry debates about the future of the dairy sectors in the UK and Ireland (Brady, 2017; Taverner, 2015). The move towards indoor livestock production has for decades been theorised within agricultural social sciences as part of an 'industrialisation' process whereby agriculture becomes less dependent on natural processes and a surrounding land base (Goodman et al., 1987). Moves towards indoor livestock production have been criticised as environmentally damaging, breaking down the social structures in rural communities and creating greater disconnect between people and nature (Goodman et al., 1987; Hansen, 2014; Hinrichs and Welsh, 2003). Studies have found year round housed systems are opposed by the general public in the UK, and the majority of the public would prefer cows to have access to pasture on animal welfare grounds (Ellis et al., 2009; Taverner, 2015; World Animal Protection, 2016). These claims are countered by the dairy industry (NFU, 2010a, 2010b).

Debates about grazing in the dairy industry have implications for agricultural sociology, the public and the agriculture industry. These debates relate to the public and industry visions of agriculture caught between imagery of an agrarian, pastoral past and a high tech, consolidated future. This paper explores and compares the sociotechnical imaginaries of dairy farming in the UK and Ireland.

The UK and Ireland make for useful comparisons to explore the politics of grazing of dairy cows. Both countries are seen to have suitable conditions for supporting grazing dairy production (Reijs et al., 2013) but their dairy systems are structured very differently. The traditional system of dairy production in the UK and Ireland has been cows grazing during the warmer months of the year, and housed during the colder months fed on grain, concentrate feed, silage (fermented grass) and hay (dried grass). A survey in 2014 found that around 31% of farmers in the UK still operate this system, with the rest giving the cattle additional feed indoors year round and 16% housing all or some of the cows year round (March et al., 2014). The figure of farms housing cows year round is given as 23% by an agricultural consultancy (Kingshay, 2018). Farms moves the herd indoors all year around to feed the cows higher energy feed leading to increase yields and for logistical reasons as over a certain herd size it is difficult to have enough pasture surrounding the milking parlour for cows to graze (POST, 2012).

Large, high output and indoor farms have raised controversy in the UK. In 2010 a planning application for an 8000 cow dairy in Lincolnshire became subject to widespread criticism and resistance (Jackson, 2013). It was claimed that this type of farm system resulted in environmental damage and poor animal welfare and threatened the social sustainability of family owned and small scale farms by increasing competition (Compassion in World Farming, 2011). The application was eventually denied by the local planning authority based on the pollution risk from manure.

The dairy sector in Ireland by contrast is much more uniform and grass based. The majority of farms operate a grazing system where all cows calve during spring and the bulk of milk production comes

from grazed grass in the spring and summer (DAFM, 2015). The removal of milk quotas in 2015 prompted ambitious plans for expansion of the Irish dairy sector, with a government target of a 50% increase in milk production by 2020 (DAFM, 2010), which is on track (Dillon et al., 2017). There have also been heated debates within the Irish dairy industry, media and public about the need for, and means of bringing about such an ambitious increase in dairy production (Brady, 2017; McCormack, 2018). Table 1 gives details of the Irish and UK dairy sectors.

Table 1 Dairy sectors in the UK and Ireland

	<b>UK</b>	<b>Republic of Ireland</b>
<b>Population</b>	67m (England: 55m) (Wales: 3m) (Scotland: 5.4m) (Northern Ireland: 1.9m)	4.9m
<b>Area</b>	242,495 km <sup>2</sup>	70,273 km <sup>2</sup>
<b>Dairy farms</b>	12,584 Wales: 1678 (AHDB Dairy, 2019) Scotland: 909 (Scottish government data) England: 7313 (AHDB Dairy, 2019) Northern Ireland: 2684 (Dairy Council Northern Ireland, 2017)	16,146 (Dillon et al., 2017)
<b>Average herd size</b>	142 cows (AHDB Dairy, 2016)	78 cows (Dillon et al., 2019)
<b>Average milk yield per cow</b>	7495 litres per cow per year (AHDB Dairy, 2018)	≈ 5000 litres per cow per year (IFA, 2017)
<b>Seasonal spring calving</b>	4% (AHDB Dairy, 2017)	90% (IFA, 2015a)
<b>Year round or autumn calving</b>		10% (IFA, 2015a)
<b>All year round calving</b>	81% (AHDB Dairy, 2017)	
<b>Autumn calving</b>	8% (AHDB Dairy, 2017)	
<b>Autumn and spring</b>	7% (AHDB Dairy, 2017)	
<b>Farms housing all or some of the cows all year around</b>	16% (March et al., 2014) 23% (Kingshay, 2018)	No figures available
<b>Percentage of dairy produce exported</b>	11% (Dairy UK, 2017)	90% (National Milk Agency, 2016)

This paper uses the concept of sociotechnical imaginaries to explore disputes about the role of grazing in the future of dairy farming in the UK and Ireland. A sociotechnical imaginary is a vision of a particular techno-scientific configuration of societal progress (Jasanoff and Kim, 2009). This paper poses the following research questions. What are the sociotechnical imaginaries of the dairy sectors in the UK and Ireland, and how are they constructed through the concepts of economic viability, environmental sustainability and high animal welfare? The use of these categories is similar to the approach taken by Levidow & Papaioannou (2013) who found that sociotechnical imaginaries of bioenergy futures in the UK were chosen based on different models of economic competitiveness and environmental sustainability. How are the sociotechnical imaginaries co-produced by material infrastructure and socio-economic forces in both countries? What lessons can we draw for wider debates about pastured based and indoor dairy systems? These questions are posed during a time of change within the dairy industry which has implications for agriculture and society more widely.

## **2. Theoretical framework**

### **2.1 Sociotechnical imaginaries**

The concept of sociotechnical imaginary was first introduced by Jasanoff and Kim (2009) conceived as a vision of the good life co-produced through specific scientific and technological configurations. The concept addressed the gap within science and technology studies (STS) of too little attention paid to the promotion of science and technology by non-scientific actors. Jasanoff (2015) defines sociotechnical imaginaries as: “collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understanding of forms of social life and social order attainable through, and supportive of, advances in science and technology.” (p.4). She stresses the word “desirable” is important because these visions are grounded in visions of what constitutes social progress.

Jasanoff and Kim (2009, 2013) use the concept to explore the distribution of public goods and risks created by a sociotechnical regime, and the kind of nations created through these imaginaries. Imaginaries are not just ideas but enable practices through their role in making sense of the world (Taylor, 2002). Sociotechnical imaginaries are made reality through influencing public and political “collective consciousness” to mobilise action (Jasanoff and Kim, 2009 p.123). This action in turn can involve the exercise of state power in relation to scientific and technological development through funding research and building infrastructure. Sociotechnical imaginaries are related to work on theory of expectations – which focuses on how hope and hype about emerging technologies serves to enact these realities in the present (Berkhout, 2006; Borup et al., 2006; Konrad, 2006). It is also related to the transition theory approach, which is generally concerned with how to bring about change at different scales (Wilson, 2007). A country comparison allows otherwise taken for granted or ‘common sense’ aspects of imaginaries to be called into question in relation to each other.

Sociotechnical imagination is rooted in Jasanoff’s theory of co-production through which science and society co-create each other. “Scientific knowledge, in particular, is not a transcendent mirror of reality. It both embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments, and institutions – in short, in all the building blocks of what we term the social. The same can be said even more forcefully of technology.” (Jasanoff 2004 p.2-3)

Sociotechnical imaginaries have been used widely within social sciences to explore normative visions of technological and scientific energy sector configurations (Ballo, 2015; Eaton et al., 2014; Engels and Münch, 2015; Kuchler, 2014; Levidow and Papaioannou, 2013), and to a lesser extent within the agricultural sector (Dentzman, 2018; Smith, 2015; Thompson, 2018). The concept of sociotechnical imaginaries is related to the concepts of agricultural paradigms (Beus and Dunlap, 1990; Lang and Heasman, 2004; Levidow et al., 2013; Shortall et al., 2019), philosophies (Thompson, 2008, 1995), and master frames (Dentzman, 2018) which explore normative visions about the future of agricultural production systems. These concepts differ from sociotechnical imaginaries because they distinguish visions of agricultural change along the lines of pre-existing ideologies which persist across space and time. The concept of sociotechnical imaginaries also shares some similarities with the analysis of frames (Shortall et al., 2015) and discourse (Mariola, 2005) within the agricultural sector. Frame and discourse analysis explore the ordering of experience (Entman, 1993) and the concept of sociotechnical imaginaries explores the constructions of imagined desirable futures however.

The concept of sociotechnical imaginaries has been criticised for focusing exclusively on high level expert visions of the good life and not including public values (Tidwell and Tidwell, 2018). This consideration is relevant to this context because it has been shown that farmers in Ireland may be sceptical of what they perceived as unified and overly prescriptive farming advice (McDonald et al., 2014; McDonald and Macken-Walsh, 2016). However, this can be seen as the strength of the concept if the aim is to explore normative visions of the integration of scientific and technological infrastructure within the social world at the level of discourse, which this paper seeks to do.

### **3. Methods**

The analysis is based on document analysis of key stakeholder documents and interviews with key stakeholders in the UK and Ireland. The aim of the document analysis was to explore the sociotechnical imaginaries described by key stakeholders and stakeholder organisations at play in the dairy sector. To achieve this, documents from government, research organisations, non-governmental organisations (NGO) and agricultural industry organisations were collected through internet searches between February and October 2018. A total of 26 Irish documents were analysed: 6 industry; 3 NGO; 12 research; and 5 government. A total of 38 UK documents were analysed: 15 industry; 11 government; 4 research and 8 NGO. A list of documents analysed is given in appendix A. The differences in numbers relate to the different structures of the sector, for instance the agricultural research and extension body Teagasc in Ireland plays a key role in dairy research and knowledge exchange to farmers. Outputs from Teagasc were classed under 'research' but had several intended audiences including policy makers, farmers and other researchers. There is no comparable partly state funded research and extension body in the UK and farmer facing outputs were here classed under 'industry'. There were more UK documents than Irish documents because documents were needed relating to the UK as a whole as well as the individual countries of England, Wales, Scotland and Northern Ireland.

Interviews were intended to build on the document analysis and provide further detail and insights into issues identified. Themes were identified in the document analysis which required further exploration. The focus on environment, welfare and economic aspects of the imaginaries emerged from the document analysis and questions about these aspects of grass based, higher input and

indoor systems were asked in the interviews as well as generic questions about challenges and opportunities in the dairy sector. Interviews were carried out between September 2018 and February 2019 and purposive sampling was used to identify key stakeholder from industry organisations; NGOs; academia and government. An excel sheet was compiled for each country with details of organisations involved in the dairy sectors. Organisations and individuals who were considered influential in the dairy sector were identified for interview, as well as organisations which may have a different perspective to the dominant view within the industry. Within organisations, individuals who worked with farmers were contacted for interview. Purposive sampling aimed to access the 'dominant' and 'mainstream' sociotechnical imaginaries within the dairy sectors, and also speak to people whose role and views could be considered to be outside the mainstream. Ethical approval for the interviews was gained from the James Hutton Institute Research Ethics Committee. Interviewees were sent an information sheet and invitation letter and signed a consent form agreeing to take part in the research. Interviewees were told that their data would be reported in anonymised form and they were not identifiable. If there was a concern that they may be identified the data was sent to them for comment before it was made public.

Interviews lasted around an hour – the shortest interview was 39 minutes and the longest was 126 minutes and were carried out over the phone, through videoconference or in person. Interviews were audio recorded and transcribed. Twenty five interviews were carried out in the UK including 16 from industry, 4 from NGOs, 3 from academia and 2 from government. Industry includes commercial actors, and agricultural and dairy industry organisations. Eighteen interviews were carried out in the Republic of Ireland including 10 from industry, 4 from academia, 1 from an NGO and 3 from government. Nine interviewees were female and 34 were male. Data saturation was reached in document analysis and interviews whereby no new themes relevant to the research questions were being identified (O'Reilly and Parker, 2013). Interviewees will be anonymised by giving them a letter corresponding to the sector they are in and a number. I will stand for industry, G for government, N for NGO and A for academia. Both the documents and the interview transcripts were analysed using the software Nvivo 12, using thematic analysis.

## **4. Results**

Three, potentially conflicting sociotechnical imaginaries were identified in both countries with different descriptions of economic viability, high animal welfare and environmental sustainability. The results also describe the emergence of the sociotechnical imaginaries through markets and policy, as well as any criticisms of the imaginaries.

### **4.1 Ireland**

Three sociotechnical imaginaries of the Irish dairy sector will be referred to as "low cost grass based expansion" "higher output grass based expansion" and "limits to expansion".

#### **4.1.1 Low cost grass based expansion**

The low cost grass based expansion sociotechnical imaginary is dominant in the Irish dairy sector. This sociotechnical imaginary involves meeting the expansion target set out by the Irish government after the removal of milk quotas (DAFM, 2010) through Ireland's existing low cost model.

### **Economics**

The economic arguments that this paper will explore are predominantly those relevant to the profitability of individual farms. The economic argument for the low cost grass based sociotechnical imaginary is that Ireland has a competitive advantage in its ability to grow grass (Thorne et al., 2017). Cereals and concentrate feed are more energy dense than grass and can increase milk yield. But the message within the dominant sociotechnical imaginary is that basing a system around increasing yields through more concentrate feed is not an economically rational thing to do. A researcher states:

A1: Some guys are basing their system around concentrate feeding. But like, ultimately, the success of that system is built around what is the profitability of that system, and we know, from all our work here, that's a substantially less profitable system than a system that is using grass better, utilising pasture well.

In Ireland there is a link between the types of dairy products produced – processed produce for export, and the production methods – the low-cost grass-based system. . Ireland has a much smaller population than the UK – 4.9 million compared to UK's 68 million (World Population Review, 2019a, 2019b) – meaning that there is not a large demand for liquid milk in Ireland all year round. Ninety percent of produce is exported in processed form (National Milk Agency, 2016). Creamy milk for processing requires higher percentage protein and fat. Milk from grass results in higher kilograms of protein and fat than milk from concentrates, making grass based production more suitable to the needs of the Irish processing industry (SafeFood, 2018). Milk for processing does not have to be produced at the same volume all year round and in Ireland 90% of cows calve in spring which means lactating cows are turned onto grass in spring and produce milk from grass (IFA, 2015b).

Policy and market structures in Ireland have also kept the sector unified and grass based. EU Milk quotas were introduced in 1984 to reduce overproduction of milk and countries were allocated a limit to their milk production. Ireland implement one of the strictest quota regimes in the EU (Donnellan et al. 2015). Quota allocation was tied to land and could not be freely traded for the first decade of quotas, keeping farms at a lower level of intensity and smaller scale than some considered economically optimal (O'Donoghue et al., 2015).

Some saw potential danger for farmers in moving away from the low cost grass based model when quotas were lifted in 2015. A report by two dairy industry stakeholders in response to the government consultation on the Food Harvest 2020 report highlights a danger in following the example of increasing yields through feeding bought in feed.

“With so many farmers poised to expand milk production following the end of the milk quota regime, there is an urgent need to promote low-cost, profitable milk production systems based on grazed grass and to resist the temptation to move into high-cost, high-risk systems and so avoid the financial and personal hardship that confront farm families when these systems break down, as has been the experience in other countries.” (Hurley and Murphy, 2015)

But stakeholders stated that advisory services, processors and government were by and large unified around the grass based message.

I2: There's a general agreement between the advisory service, the researchers, the co-ops, the farming organisations, Farmers' Journal, that, you know, the grass based system is the way that we should go.

Advisory services in Ireland are also more consolidated than those in the UK. The main provider of advice to farmers in Ireland Teagasc, which is part funded by the Irish government, has advocated the low cost grass-based system throughout its history (O'Dwyer, 2015).

Most interviewees stated that farmers have not changed system away from dependence on grass since quotas were lifted. But difficult weather conditions in 2018 meant that farmers did feed more concentrate than usual because there was not enough grass and some stated that there was a risk of farmers continuing with this system.

### **Environment**

The Irish low cost grass based model was framed in documents and interview as inherently environmentally friendly.

"Ireland's extensive, low-input grass-based production systems are the foundation of its green credentials [...]" (DAFM 2010 p.5)

The Irish dairy system is seen as having lower greenhouse gas emissions per unit of produce than competing sectors: a report which showed Irish milk to have the lowest greenhouse gas (GHG) emission footprint in the EU (Leip et al., 2010) was quoted by interviewees and in documents (O'Donoghue et al., 2015). Dairy farming is a source of a number of greenhouse gas emissions: methane from enteric fermentation produced by the cow; carbon dioxide for embedded fossil fuels in feed, machinery use and loss of carbon from soils; and nitrous oxide from fertiliser and manure (FAO, 2009). The carbon stored in grassland soils is seen as a factor making the Irish system more environmentally friendly than systems which buy in non-forage feeds, where soils tend to store less carbon (DAFM 2010; Leip et al., 2010).

Environmental sustainability is framed as a unique selling point for Irish agriculture and a market opportunity.

"Ireland's historic association with the colour green is linked to our unspoilt agricultural landscape and our temperate climate. The modern use of 'green' to identify concern for the natural environment has, for some time, been recognised as representing a natural marketing opportunity for Irish agri-food to build on." (DAFM 2010 p.6)

Based on this marketing potential a national Origin Green marketing strategy was developed through Bord Bia, the Irish Food Board (Bord Bia, 2019).

The environmental credentials of the Irish low cost grass based system are, however, being called into question. There are concerns about the impact of increasing cow numbers on greenhouse gas emissions, ammonia emissions and water quality in Ireland. Ammonia is an air pollutant produced from animal manure and fertiliser which affects human health and natural habitats (FAO, 2009). Ireland is currently not meeting EU greenhouse gas emissions targets or ammonia targets (Climate Change Advisory Council, 2018). Several interviewees expressed concern that Ireland's poor

performance in meeting international targets could in the long run compromise the image portrayed by Origin Green.

G1: It'll take one bit of bad press on ammonia for outright war in the next couple of years in Ireland. Because if the [European] commission decide, and rightly so, because we're in breach of the directive, to bring Ireland Inc. to the European court of Justice. And we end up daily fines, it's not going to look good. [...] We can't continue apace without recognising the effects that we're having on the environment.

Claims about the environmental sustainability of the Irish dairy sector are founded on the sector's grass base. However, as the sector expands meeting international greenhouse gas reduction targets and curb nutrient leaching from fertiliser and manure application becomes more challenging.

### **Animal welfare**

The grass based production systems is also perceived as a welfare marketing advantage for Irish dairy produce: "This is because consumers perceive pasture-based systems as more 'natural' and, therefore, better for cow welfare." (Boyle et al., 2017). Interviewees reinforced this view.

I1: I fundamentally believe that, you know, there is something attractive about letting animals, allowing animals to be outdoors for the greater proportion of the year. To me, that's where animals should naturally reside: outdoors, at pasture.

There was discussion of an umbrella label under which Ireland could market its 'grass based produce' stipulating a minimum percentage of forage in the diet. One of the main challenges within this sociotechnical imaginary was seen to be communicating the uniqueness and benefits of the Irish production system to consumers. Stakeholders stated that other European pasture based labels allow access to graze, but the cows don't actually graze and may spend only a few hours on grass,:

A1: We do have frustrations that some European countries are saying they're raising them naturally, it's confining access to grass. And sometimes, it's only access outdoors. So that is a debate that needs to be cleared up in the minds of European consumer, I suppose, you know?

However, expansion is also seen as bring welfare risks, such as lack of investment in farm infrastructure needed to improve welfare as farm sizes increase and inadequate assurance in relation to animal welfare in the primary dairy herd certification scheme in Ireland the Bord Bia Sustainable Dairy Assurance (Boyle, 2017).

There are also concerns about the increase in Ireland's 'bobby calf' or cull calf industry. Expansion has led produced surplus calves, which are sent to the abattoir, instead of going into the beef sector has been the case in the past. While the scale of this cull calf trade is still far smaller than in other dairy sectors, such as the UK and New Zealand, it is seen as a welfare challenge.

I3: I don't think the dairy industry in Ireland wants a bobby calf industry that they have in New Zealand and Australia, and that's the advice we're getting from the industry in New Zealand as well, and Australia, not to go down that route, you know, they have a bad image on the back of it. And Ireland has a green clean image when it comes to dairying, and it's one that we don't want to throw away overnight either.

Thus, similarly to the environmental dimensions of the low cost grass based system, positive welfare is positioned as a marketing advantage but there are calls for more research and industry initiatives to demonstrate and improve welfare as the sector expands.

#### **4.1.2 Higher output grass based system**

A minority of stakeholders within the Irish dairy sector are advocating for the expansion of the industry through a higher output system.

##### **Economics**

The reasons put forward for deviating from the dominant sociotechnical imaginary of the low cost grass based system relate to a lack of land for expansion, fragmented farms and a lack of labour to deal with expanding cow numbers (Lyons farm, 2018). The answer to these problems is seen as increasing yield per cow through the use of higher yielding breeds and more energy dense feed. This system is framed as more realistic and feasible for many farmers than expanding production through the low cost grass based system alone.

I4: [...] it's very difficult to survive just on grass on its own. [...] if it's [milk price] returning twenty eight, thirty two cents a litre, it's more viable to pay to feed some concentrate to the cows. It's [the low cost grass based system] not suited for everyone.

The higher output system is still seen as very much within the unified grass based system championed by the Origin Green scheme. An academic describes the merits of the higher output system:

A2: It's still sticking true to the grass system. So 75% of the diet is grazed grass or grass silage. Cows are out from February to November. So all of that is true to the Irish story and Origin Green, and that story of extensive grass based, more natural production.

Despite this sociotechnical imaginary being framed as only marginally different from the dominant low cost imaginary, some interviewees see any support for higher feed inputs as posing a dangerous precedent.

I5: If people listen to them [those advocating a higher output system] they're on course to do real damage, financially. People will work harder for far less money in their pockets. Have far less time for their family, work life balance. If people take them seriously, they'll do real damage to real people.

Thus, what is framed as quite a minor change in system, can provoke strong reactions if it is seen as a step in the wrong direction away from the low cost grass based model which would compromise farm profitability and farmer wellbeing.

##### **Environment**

It is also argued that this system has environmental benefits because higher yield per cow means that the cow's methane emissions are spread across more litres of milk, resulting in lower GHG emissions per unit of milk (UCD, 2018). Methane is one of the largest greenhouse gas sources from

dairy farming and feed which is more digestible, such as concentrates and cereals, results in fewer GHG emissions than less digestible grass. A researcher states:

A2: Expanding cow numbers are an issue in terms of the environmental impact. So every cow, it's assumed they excrete the same amount of nitrogen, the same amount of methane. So, the more cows you have, from an environmental perspective the greater the issue that is. [...] We could probably milk as much with 90 cows as someone else might with 120.

While the low cost grass based model focuses on the soil sequestered in carbon in grassland as the source of the claim that grass based production is the most greenhouse gas efficient production system, this system also focuses on increasing milk production per cow through additional concentrate feed to reduce cow numbers and so methane and nitrous oxide emissions.

### **Animal welfare**

Arguments around welfare do not feature prominently in the higher output grass based sociotechnical imaginary, but it was suggested that animals eat more energy dense feed under this system which may alleviate some cases of hunger in animals that just subsist on grass.

A3: We mightn't push the cows as hard as a low input system would, with a jersey cross, a smaller bodyweight cow. And what I mean by that is you can force cows to graze out to a particular residual and I would say we're a bit more lenient than that because if you restrict cows you reduce production.

A similar argument is put forward in the UK context as will be seen in sections 4.2.1 and 4.2.2.

#### **4.1.3 Limits to expansion**

There have also been voices from within and outside the dairy industry critiquing the ambitious government plans for 50% milk production expansion by 2020 and/or the means of achieving these.

### **Economics**

Within the industry criticisms of expansion relate to farmer wellbeing and lifestyle, and whether farmers' interests are compatible with expansion. There were suggestions that expansion is putting more stress on farmers because of debt and the need for new skills and additional labour. Within the dominant sociotechnical imaginary these concerns are challenges to be met through more training and advice for farmers. But there is also a marginal sociotechnical imaginary that sees these issues as signs expansion has gone too far.

N1: There was a local young farmer here and he was being hailed for increasing his herd size and he was being praised. He's ended up with real mental health problems. He got too many loans he couldn't afford to pay back and he couldn't afford to feed his animals. His business has gone to pot. There's too much pressure on the farmers.

Some stakeholders stated that conversations about expansion needed to be reframed away from productivity and profitability towards quality of life and strategic planning to take farmers' wellbeing into account to a greater degree.

## **Environment**

Certain stakeholders voice concerns about dairy expansion given the negative environmental impacts. The Environmental Pillar, an advocacy coalition of 27 Irish environmental non-governmental organisations produced a consultation response in 2012 critiquing the environmental implications of the 2010 government Food Harvest 2020 report:

“The desire to increase employment and farm incomes in the short-term should not be done at the cost of destroying the fundamental wealth that supports all human activity for this and future generations.” (Environmental Pillar, 2012 p.3).

The Citizen’s Assembly, a participatory democracy exercise in which a panel of citizens makes recommendations to government, produced controversial recommendations that farmers should be taxed for greenhouse gas emissions (The Citizen’s Assembly, 2018).

Several interviewees stated that the scale of the dairy sector should be curbed because of environmental concerns. Interviewees suggested a de facto environmental quota system that was in operation in the Netherlands that limits the number of animals dairy farmers can keep on environmental grounds.

## **Animal welfare**

Within this sociotechnical imaginary the increase in the number of animals in Ireland following the removal of quotas is framed as creating significant welfare problems that should lead to the curbing of the sector. A cold spring in 2018 followed by a hot, dry summer made conditions very difficult for farmers, dubbed the fodder crisis (Brady, 2018). Within the dominant low cost expansion sociotechnical imaginary stakeholders stated that there were lessons learned from the fodder crisis, but it was not a challenge to the legitimacy of the system. Other actors however state that it showed that the sector had expanded too much:

N1: There’s just too many animals in Ireland now. I mean last winter was a disaster with the fodder crisis. Animals literally starving to death and being sent to slaughter because the farmer couldn’t afford to feed them. Then in the summer we had the drought. So they’ve been pushed and pushed and pushed to increase herd size without thinking about how they’re going to feed them, what they’re going to do with the calf offspring and all that sort of stuff.

The fodder crisis, combined with lack of improvement to facility, and the burgeoning cull calf industry and controversies around the live exporting of young calves (Phelan, 2018) has led to questioning of expansion plans. However, this is a marginal sociotechnical imaginary in Ireland.

## **4.2 UK**

Three sociotechnical imaginaries of the dairy sector in the UK were identified: “Any system can work” “Indoor, large and high output systems are optimal”, and “pasture based production”.

### **4.2.1 Any system can work**

## **Economics**

In contrast to the dominant low cost grass based sociotechnical imaginary in Ireland which frames one type of system as the most rational and beneficial from an economic, environmental and welfare point of view, the dominant sociotechnical imaginary within the UK industry argues that the environmental, welfare and economic attributes of farms are largely *independent* of the type of system. The dominant sociotechnical imaginary in the UK is that any system can 'work' if it is managed well.

A1: What makes a system work or not is the attention to detail within the system. So I think we have umpteen pointless discussions about whether we should have a spring calving grazing system or a housed system, I actually think that that's not the question. I think the question is you form your overall system with a whole series of things in mind: what does your milk buyer want, what is your grass growing conditions like, how many cows have you got?

The 'optimal' system is framed as depending on the geographic location – the climate, topography which determines what crops can be produced; the market conditions – the type of contract the farmer is on; and the preferences of the farmer.

The main economic argument within this sociotechnical imaginary is that the economic performance of a farm is not determined by the type of system it operates but rather any type of farm can be profitable. A government and industry report on the future of the dairy industry states:

"Our evidence shows that system and herd size are not predictors of profitability. Any system of any size, run well, can be profitable and sustainable. We want to grow the whole industry and see a role for small, medium and large herds." (Dawson et al. 2014 p.14).

In this UK sociotechnical imaginary, the message is that grass use should be optimised in *any* system, not just a low cost, grazing one practiced in Ireland (DairyCo 2013). The role of grazing within this sociotechnical imaginary is also framed as not as straightforward in the UK as in Ireland.

A1: I'm not always convinced that grazed grass drives that lowering of cost for everybody. So it depends on how – what the grass growth is and what other feeds are available. [...] There are situations where you could say buying in some feed would be a better option than growing more grass or having more land to grow more grass, it depends on the price of land and all those sorts of factors.

The message from Teagasc in Ireland is also that the costs of producing forage and forage quality can vary, but this is not used to the question the merits of using forage as a primary feedstuff, but of the need for high quality forage management. Whereas in the UK sociotechnical imaginary it is not a given that forage is more beneficial than other feeds. A benchmarking report by DairyCo states:

"However, relationships between milk from forage and total cost of production is complex. For example, benefits resulting from a higher use of forage can be eroded by unnecessary expenses related to the production and feeding process of forage." (DairyCo, 2013, p.30.)

The UK dairy sector is structured very differently to Ireland which means it cannot produce as much milk from grass. The UK's larger population of 66 million creates a larger demand for liquid milk all year round: almost half of milk produced goes onto the liquid milk market (Dairy UK, 2017), compared to Ireland's 10%. The demand for fresh milk year round means 81% of herds calve all year

round (AHDB Dairy, 2017). Herds that calve all year round or where all cows calve in autumn cannot rely as heavily on grass for feed intake compared to herds where all cows calve in the spring.

In addition, policy was implemented differently in the UK compared to Ireland. In the UK milk quotas were implemented in a more liberal manner with more room for trading in quotas, and prices based on milk supply and demand conditions (O'Donoghue et al., 2015). The UK was operating below its quota allocation before quotas were removed and quotas did not limit the sector in the way it did the Irish sector (NFU, 2015). In contrast to Ireland's co-operative milk purchasing system the state monopoly body the Milk Marketing Board which bought all milk, was disbanded in 1994 to liberalise the market, opening up the way for greater processor and retailer control of the supply chain (Banks and Marsden, 1997).

In contrast to the relatively unified and consolidated agricultural research and extension services in Ireland, advisory and extension services in the UK have been increasingly privatised since the 1980s, (Garforth et al., 2003). An industry stakeholder stated that the diversity of systems in the UK makes it difficult for dairy organisations to show leadership:

I1: But they've got so many hats on and so many people they've got to keep on board that it's a job to be massively effective for any of those particular sectors.

In the UK a diverse range of actors advise a diverse range of farmers, making the 'any system can work' sociotechnical imaginary the dominant one, and meaning the role of grazing within dairy systems is presented as more complicated than in Ireland.

### **Environment**

Within this sociotechnical imaginary no system is seen as inherently more environmentally friendly than another: "Dairy farmers, regardless of scale or management system, take their environmental responsibility very seriously." (NFU, 2010a). An industry stakeholder states:

I3: It again becomes an aspect that's quite difficult to quantify on a national level versus an individual farm level. And ultimately it does come down to, on this individual farm or plot of land, what is the best, most efficient use that we could make of that land. And is it grazing cattle, is it grazing something else, is it...ploughing it up and putting it into corn to feed cattle? As I say, I don't think there's an overall 'this is the answer'.

The industry stakeholder states that environmental conclusions are only possible a micro, farm scale rather than a system scale.

### **Animal welfare**

The dominant sociotechnical imaginary in the UK is about decoupling welfare outcomes from the type of production system. Rather than the type of system, the main factors seen to affect welfare are the quality of the facilities and crucially the quality of stock keeping. The National Farmers Union dairy strategy states that one of their objectives is to bring about:

"A recognition that welfare standards are underpinned by the suitability of the farm system to meet the needs of the animals and the skills of the stockman, and that the type of production system does not dictate the health and welfare status of the cow." (NFU, 2010b p.4)

The quality of stock keeping and management is seen as the key to high animal welfare in this sociotechnical imaginary.

I3: So honestly, generally I think it's [indoor dairy farming] a totally viable system, provided that it's managed properly and globally I've been on some very good 100% housed systems and they've been really, really good and then you go to other ones and you go 'maybe these cows might be better outside'. But again, it comes down to management because I do suspect that on the better farms that are housed, they'd also be very good at doing grazing and for farms that don't do good housing, would probably be no better doing grazing because it seems to be a management issue, not a system issue.

Arguments about animal welfare in indoor and high input systems will be explored further in the next sociotechnical imaginary.

#### **4.2.2 Indoor, large and high output systems are optimal**

As described in the background section, the UK dairy sector is made up of greater diversity of systems than the Irish sector. While, indoor, large and high output farms are separate categories, there is evidence that indoor farms tend to be bigger and higher producing (March et al., 2014). And arguments relating to all three were found to be commonly linked in the document analysis and interviews, so these systems will be grouped under one sociotechnical imaginary.

#### **Economics**

During the controversy raised by the Nocton dairy planning application in 2010, described in the introduction, industry stakeholders defended the need for indoor dairy farming through a productivist argument that indoor farms are needed to increase production to feed a growing world population (NFU, 2010a). One of the main economic arguments in favour of larger herds is increasing economies of scale – fixed costs are spread across a higher output (POST, 2012).

“National dairy industries that do respond to the growth in demand, by growing their output, will enjoy improved efficiencies of scale in investment, innovation and efficiency. As the global benchmark moves forward, it will become harder and harder for the British industry to defend even a static position.” (NFU, 2013p.16).

As well as increasing in size increasing use of inputs to increase outputs is still framed as rational in the UK context:

“As well as efficiency potential, increased output could be achieved as a result of direct investment in productive capital and infrastructure (cows, land etc) and by increasing inputs for yield, provided that market signals support such investment by farmers.” (NFU, 2013 p.19).

Here increasing size and increasing output by using more inputs is framed as part of the continued way forward to UK dairy farmers, in contrast to the dominant imaginary in Ireland where increasing feed inputs is not framed as desirable.

#### **Environment**

Larger, higher output and indoor systems are defended in environmental terms through the argument detailed in section 4.1.2 on the higher output Irish imaginary that higher output systems can be more efficient in terms of greenhouse gas emissions per product than pasture based systems.

“[...] the current advice on climate change and methane emissions has even suggested that there is usually a reduction in methane emissions when cattle are housed compared to those on pasture due to the improved efficiency of milk production.” (NFU, 2010a).

This is in direct contrast to the statement on greenhouse gas emissions in the dominant Irish sociotechnical imaginary that the Irish pasture based system was shown to produce lowest GHG emissions per litre of milk.

There are different and additional environmental concerns raised by larger and indoor units compared to smaller and pasture based farm. Larger and indoor units produce a large amount of slurry per unit of land, and result in more ammonia emissions than smaller and pasture based dairy systems (Defra, 2018). This is framed by some as under control through existing legislation and better deployment of technology in future (POST, 2012).

However, there are also signs that pollution from large scale and indoor farms is becoming problematised. The UK Department of Environment, Food and Rural Affairs (Defra) consulted on a clean air strategy in 2018 which proposed introducing the requirement for large dairy farms to seek environmental permits from 2025 in England, similarly to pig and poultry units, because of ammonia emissions (Defra, 2018). This suggestion has been opposed by the NFU (NFU, 2018). A move to require large scale dairy units to obtain a permit under the Environmental Permitting Regulations in England would further differentiate between larger and smaller, and indoors and pasture based production systems.

### **Animal welfare**

Arguments are made within the industry to disconnect the type of production system from welfare outcomes, as described in section 4.2.1. A letter from the government appointed Farm Animal Welfare Committee (FAWC) in 2010 at the time of the Nocton dairy controversy outlines the potential advantages and disadvantages of keeping cows indoors, which include the ability to target diet to the cows' needs, protection for adverse weather, reduced risk of certain infections and protection from disease spread by wildlife (FAWC, 2010). It is also stated that higher yielding cows need a higher energy density diet which they might not be able to get from grazing (POST 2012). Thus, just as 'milk' was not the same thing in the UK and Ireland, 'cows' are not the same in the UK and Ireland. More Holstein genetics are used in the UK, meaning cows are bigger, more productive and require more calories than Irish cows with more Jersey and Friesian genetics.

Many interviewees spoke from their personal experience to attest that indoor systems could be as good or better than outdoor systems.

I4: And I know someone down in the south and he says the viability of land around me to graze my cattle isn't there. And actually, I've found that welfare and, in his personal system, his welfare improved, he brought them inside he's able to manage rations better. He was able to have that connection with the cows more because he's in amongst them every day so, for him, that worked a lot better.

Here the stakeholder states that facilities are adequate and the stock keeping is attentive, and they are potentially more comfortable inside than outside.

### **4.2.3 Pasture based production**

There is a marginal pasture based sociotechnical imaginary in the UK which is supported through similar arguments to those made in the Irish context.

#### **Economics**

A report by the World Society for Protection of Animals (now World Animal Protection) makes the same economic argument as in the Irish context, that the UK has a competitive advantage in its ability to grow grass and should make this by focusing on grazing systems (WSPA 2011). There were also calls for more focus on grass production and utilisation in government commissioned reports in Wales and Northern Ireland (Expert Working Group on Sustainable Land Management, 2016; Richardson, 2015).

An analysis of dairy systems in Europe produced by the Irish organisation Teagasc claims that the move away from a predominantly grass based system towards more concentrate feeding has damaged the profitability of the UK dairy sector:

“Many producers increasingly found themselves land constrained and increasingly dependent on feed supplementation in their grazing system. However, higher stocking rates have led to increasing use of concentrate feeds and this has led to an increase in production costs and falling dairy farm incomes.” (Donnellan et al., 2015).

Thus, according to this view the UK has undergone the transition away from a pasture based system that stakeholders fear may happen in Ireland. A graph in a report by the Expert Working Group on Sustainable Land Management (2016) does show a decrease in milk produced from forage in Northern Ireland since 2000. This view is strongly rejected in the dominant UK sociotechnical imaginary that profitability is not determined by system, as we saw in the quote from NFU (2013) which stated increasing yields through increasing inputs is still rational.

#### **Environment**

Similar arguments about the environmental benefits of grass production were made within this sociotechnical imaginary to those made in the dominant sociotechnical imaginary in Ireland.

N1: [...] we also think that grass in a rotation is good for soil and sustainability and reducing chemical use and intensive farming. So, the proper place of the cow is eating grass; either permanent pasture or rotational pasture that's maintaining a sustainable system.

While promoting the pasture based system above other systems was a niche position in the UK, several stakeholders suggested that government policy may in future favour grazing systems because of environmental benefits. A Northern Irish stakeholder states:

I5: I can see a mood swing within our own department of agriculture focusing on more grass based systems, you can actually begin to see that.

The stakeholder stated this is primarily because of concerns about ammonia emissions in Northern Ireland.

I5: Ammonia emissions are significantly less for those who graze cattle outdoors compared to those who house all year round and I can see almost like an environmental constraint for ammonia for those who house all year round.

There was also a suggestion of a potential for government payments for the public good created by pasture farming from several stakeholders. A key government stakeholder suggested that payment for public goods, even if it wasn't targeted at farmers that graze cows, would benefit extensive farms with a larger surrounding land base more than higher output farms:

G1: The way in which we structure our future funding will have an impact. If we're paying for the delivery of outcomes like improved water quality and improved air quality. [...] A more extensive dairy farm will find it much easier to deliver these outcomes in substantial quantities than an intensive dairy farm. Because their whole business seems to be based upon a willingness to have externalities that are socially inappropriate.

Thus, there were suggestions that the pasture based sociotechnical imaginary may in future be favoured through government policy.

### **Animal welfare**

Certain stakeholders claim animals need access to pasture for welfare reasons and animal welfare cannot be adequately supported in fully housed systems. During the Nocton dairy controversy the NGOs Compassion in World Farming (CIWF) and the World Society for Protection of Animals questioned the legality of indoor dairy farming, as to whether it contravened the Animal Welfare Act 2006 which stipulated that animals "need to be able to exhibit natural behaviour patterns" (Compassion in World Farming, 2011). CIWF claim that indoor housing, particularly in large groups, can lead to higher levels of aggression among cows as cows cannot adequately express social behaviour in a confined space and social relationships need to be continually renegotiated in large and changing herds (Compassion in World Farming, 2011). The Royal Society for the Protection of Animals (RSPCA) produced a position statement on grazing in 2017 in which they stated that scientific evidence has shown access to pasture is beneficial for cows in terms of certain health outcomes, and cows do show some preference for accessing grazing (RSPCA, 2017).

A number of pasture based labels have been launched in the UK (Free Range Dairy, 2019; Pasture Fed Livestock Association, 2019) and several supermarkets including Waitrose, Marks and Spencers and the Co-op source their own brand liquid milk exclusively from grazing herds. These labels are based on claims about the welfare of the cows and the naturalness of the produce (ASDA, 2017).

However, many interviewees expressed opposition to these labels claiming that they misled consumers and created division and confusion within the sector. Even though an industry stakeholder preferred to see cows in fields from his personal point of view, he stated:

I6: We don't want an industry that differentiates itself too much because it sets one against the other and that's not a good thing. Farmers live in the parish, they communicate, people that run

factories don't really communicate, they are competitors, farmers don't see themselves socially as competitors but they will do if we get more and more brand differentiation.

Another industry stakeholder states that these labels are about tapping into a market demand for pasture based milk, but that is not to say that claims about welfare and environmental credentials are true.

17: I think it's entirely unhelpful in the grown up conversation we've got to have about, what does modern farming look like, and how can we best meet the needs of cattle.

This is in stark contrast to the marketing strategy in the Republic of Ireland which aims to capitalise wholeheartedly on consumer's positive associations with grass fed milk. Despite a similar climate and geography, the dominant sociotechnical imaginaries in the UK and Ireland moving in markedly different directions in relation to the role of pasture. Table 2 summarises the results of the different sociotechnical imaginaries in the UK and Ireland.

Table 2 Sociotechnical imaginaries of the dairy sectors in the UK and Ireland

<b>Ireland</b>	<b>Economics</b>	<b>Environment</b>	<b>Animal Welfare</b>
Low cost grass based expansion	Grass is lowest cost feedstock. Systems maximising grass use maximise profits.	Lowest greenhouse gas and ammonia emissions. Carbon sequestered in grassland important.	Grazing is important for animal welfare in terms of health and ability to express natural behaviour.
Higher output grass based system	Feeding limited additional concentrate feed can increase milk yield per cow and is still economically rational.	Increasing milk yield per cow through more concentrate feed reduces greenhouse gas emissions per cow and per litre of milk.	Feeding additional concentrate feed can relieve hunger in animals that may struggle to get adequate nutrition from grass.
Limits to expansion	The dairy industry may be expanding too much – individual farmers are suffering financial consequences.	Expansion has brought about negative environmental consequences through water pollution, greenhouse emissions and ammonia emissions.	Animals are suffering because farms expanded too quickly and too much without adequate infrastructure.
<b>UK</b>			
Any system can work	The profitability of a farm is not determined by the type of system.	The environmental sustainability of a farm is not determined by the type of system.	Animal welfare is not determined by the type of system.
Indoor, large and high output systems are optimal	Large, indoor and high input farms can be profitable by pursuing economies of scale.	Large, indoor and high input farms may have the capital to invest in environmental measures.	Large, indoor and high input farms may have the resources and staff time to optimise animal welfare.

Pasture based production	Grass is lowest cost feedstock. Systems maximising grass use maximise profits.	Lowest greenhouse gas and ammonia emissions. Carbon sequestered in grassland important.	Grazing is important for animal welfare in terms of health and ability to express natural behaviour.
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## 5. Discussion and conclusion

In the above analysis we can see that there are different sociotechnical imaginaries within and between the UK and Irish dairy sector about what an economically competitive, environmentally sustainable and high welfare dairy sector looks like. Since the cultural turn within rural sociology and agri-food studies in the 1990s, there has been extensive exploration of the cultural dimensions of agriculture: how change within agriculture due to technical, economic and policy factors is mediated through cultural values (Pannell et al., 2006). The disciplines have also embraced the 'ontological turn', taking seriously materiality within agri-food systems (Goodman, 2001; Linn, 2018), and more-than-human subjectivity (Donati, 2019; Phillips, 2014). But there is arguably less analysis of the co-shaping of materiality and norms at the level of sector wide visions, than there is at the level of on the ground practices. Jasanoff and Kim's theory of sociotechnical imaginaries allows for an exploration of how overarching visions of desirable agricultural systems are co-produced by material infrastructure, policy, markets, science and norms. This section disentangles the origins of the sociotechnical imaginaries further and draws lessons for discussion of pasture based and indoor systems.

Sociotechnical imaginaries are partly produced by market and political realities in the country. The visions within the UK and Ireland are a challenge to the other visions within that country: the idea that cows need to graze is a challenge to the idea that any system can be high welfare, but are they a challenge to the other country? Jasanoff (2015) states "Comparing across social and political structures not only helps to identify the content and contours of sociotechnical imaginaries but also avoids the intellectual trap of taking as universal epistemic and ethical the assumptions that turn out, on investigation, to be situated and particular." (p.24). We can ask if it is legitimate to compare the 'truth' of claims across countries or are they context dependent?

We saw how different market structures, policies and the material infrastructure led to significant differences between the two sectors: Ireland's unified grass based, export focused system came about because of Ireland's small population with low demand for liquid milk all year round; EU quotas implemented in a restrictive way; and consolidated research, knowledge exchange and processing facilities. In contrast the UK's far higher population creates a greater demand for liquid milk; more liberal implementation of EU quotas; and fragmented research, knowledge exchange and processing infrastructure has led to a diversity of systems and larger and higher output farms than Ireland.

As the results showed, the sociotechnical imaginaries shape and are shaped by material differences between what exactly 'cows' and 'milk' are in both countries. The milk produced in Ireland used for processing needs high levels of protein and fat which is favourable to a grass based system. Whereas in the UK, volume is often more important than solids, meaning grass is not as important in the diet. In the UK, cows are generally bigger, higher yielding than in Ireland, meaning cows may require more

concentrated, energy dense feed than grass can provide. Thus, as argued by many UK interviewees, the question as to whether cows 'should' have access to grazing can depend on the type of cow in question. This relates to arguments made within the social sciences that animals do not have an essential 'nature' but their subjectivity is co-produced by the technologies, infrastructure, land and people on a farm (Holloway, 2007; Miele, 2016). To these insights we can add that animals are shaped by the very agricultural markets they exist within: the types of dairy market shapes the types of milk produced and the types of cows that produce that milk. Here, it is claimed by some that the process of adapting cows to the market, for fresh year round milk or processed seasonal milk, is so far advanced that the cows are now different beings with different ethical considerations at play.

However, to stop at an exploration of why the UK and Ireland are so different would be to elide the real contradictions that exist in arguments supporting the sociotechnical imaginaries. And the interesting part of the analysis is exploring how an 'is' becomes an 'ought': the Irish sector is grass based and low cost and the dominant sociotechnical imaginary is that the Irish sector should stay grass based and low cost. The UK sector is diverse, and the dominant sociotechnical imaginary is about merits of diversity.

The sociotechnical imaginaries described in this paper were based on a variety of sources and claims – from scientific claims, personal experience and personal and institutional beliefs and norms. Many of the arguments made are not intended to be context specific but are presented as universal, objective claims. Claims in the dominant sociotechnical imaginary in Ireland that grass is always the most viable feedstock were at odds with claims in the UK that whether grass is best is more complicated and context dependent. To some extent this reflects the more complicated systems in the UK, but it is also a matter of emphasis. It was pointed out in the more marginal higher output expansion imaginary in Ireland that Irish farmers also struggle to get access to enough land to graze while expanding, but the message within the dominant sociotechnical imaginary did not take this into account to compromise or equivocate on the merits of grass. In the UK grass was framed as important in any system from indoors to pasture based, rather than the emphasis being on grazing systems.

Similarly, there was a clear message in the dominant Irish sociotechnical imaginary that animal welfare is better if cows have access to pasture. This was not the message in the dominant UK imaginary, but rather welfare can be high in any system and outcomes depend on management and infrastructure.

There were also contradictory claims in relation to environmental sustainability: that Ireland's low cost grass based system is the most environmentally friendly, or that using higher yielding cows which eat more non-forage feeds is more environmentally friendly. These differed in their emphasis on carbon sequestration in grassland soils or methane emissions per cow and by extension reducing the number of cows as the most important issues. The best way of tackling ammonia emissions also differed between imaginaries: whether ammonia emissions from large and indoor herds could be managed adequately through technology and current legislation, whether additional planning legislation was needed or a move towards smaller and grazing herds.

The sociotechnical imaginaries are not entirely constructed by the market and political realities in the countries as the different imaginaries *within* each country showed. It is interesting to note that the marginal higher output imaginary in Ireland had similarities with the dominant imaginary in the

UK that there are merits to higher output systems. And the marginal pasture based imaginary in the UK had similarities to the dominant Irish low cost grass based imaginary that there are economic, environmental and welfare benefits to grazing. The different imaginaries were seen by some as feasible in both countries.

A common response to situations involving scientific disagreement is to call for more research to be carried out to resolve the issue (Sarewitz, 2004). However, the disagreements at the heart of the different sociotechnical imaginaries suggests there is not a lack of knowledge but what Sarewitz (2004) calls an 'excess of objectivity': "[...] scientific uncertainty, which so often occupies a central place in environmental controversies, can be understood not as a lack of scientific understanding but as the lack of coherence among competing scientific understandings, amplified by the various political, cultural, and institutional contexts within which science is carried out." (p.385). Within science and technology studies, truth is not considered to reside in scientific claims alone but in the assemblage of institutions and policies with their own normative culture that co-produce this truth (Jasanoff, 2004). Highlighting the co-production of scientific knowledge does not undermine any of the specific scientific claims, rather it points to a feature of all scientific research. As Sarewitz (2004) states "the problem is not 'good' versus 'bad' [science] but 'ours' versus 'theirs'" (p.390). The dominant sociotechnical imaginaries in the UK and Ireland are not only different because the contexts are very different, but these contexts lead to the production of different truths which become common sense that informs desirable futures.

One of the most visible and potentially contentious area where these scientific discussions are likely to play out is through grass based certification schemes. The science produced in both countries to support market mechanisms will be informed by the sociotechnical imaginaries it is positioned within (Allaire and Wolf, 2004). Within Ireland the challenge was seen to establish a grass based market identify that differentiates Irish produce from European competitors where animals do not graze for as long, and communicate the perceived advantages of grazing to consumers. Within the dominant UK sociotechnical imaginary, differentiation based on grazing was eschewed because it was seen to create divisions. Given the evidence that the public prefer cows to graze (Taverner, 2015), the Irish sector with its unified grass based message, Bord Bia marketing board and consolidated exporting arguably have an easier task appealing to consumers. A report by the journalist and researcher Tom Levitt (2018) argued that the UK dairy sector needed greater market differentiation and value addition for milk products (though not in terms of grazing practices). It may be difficult to produce differentiated products that both appeal to consumers and are acceptable within the mainstream industry.

Sociotechnical imaginaries are usually analysed as products of state policy (Jasanoff, 2015). The sociotechnical imaginaries in these examples are also produced by different industry institutions and actors, which may or may not be supported by the state. Ireland's dominant low cost grass based expansion model involves hybrid industry-state governance. It was a government report that first proposed the ambitious plans for 50% expansion of production after quotas were removed (DAFM, 2010), and the state contributes to research, advisory services and marketing of Irish dairy produce within this dominant imaginary. The UK in contrast is characterised by greater diversity and privatisation of marketing, agricultural research and advisory services (Garforth et al., 2003). Neoliberalism in the UK has led to decreased state governance and greater industry and retailer governance of areas including animal health, welfare, food safety and environmental sustainability

(Buller and Roe, 2014; Richards et al., 2013). There were suggestions in the UK that policy makers may begin to favour the pasture based dairy production because of the lower ammonia emissions and perceived positive environmental benefits. Any measures which are perceived to favour pasture based systems are likely to be politically difficult within an industry where the dominant sociotechnical imaginary denies systems differences.

There were also differences between the countries in the UK in relation to the role of pasture. The importance of pasture within different countries in the UK may also diverge, but it is beyond the scope of this paper to explore this in detail. Brexit is a major challenge looming on the horizon for both the UK and Irish sectors but it was beyond the scope of the study to explore the implications of different Brexit scenarios for both countries. There are also geographical differences within and between the countries which create favourable grass growing conditions to different degrees that may influence attitudes to grazing in the UK and Ireland, which is beyond the scope of this paper.

If claims about indoor and pasture based dairy systems are produced and communicated with the assumption that objective, value-free science will resolve issues then this is surely a mistaken assumption. Within STS the claim is made that science underpinned by different assumptions and values can make controversies worse rather than resolve them (Sarewitz, 2004). When the values of economic viability, environmental sustainability and high animal welfare are asserted and backed up by science within different sociotechnical imaginaries, they must not again be black boxed. A productive way to address challenges in both countries would be a need to engage, within the industry, with policy makers and the public with to the meanings of these concepts and thorny issues such as meaning and role of the 'natural' within agriculture, the extent of appropriate human impact on the environment, our responsibilities to animals within livestock systems, and what constitutes a desirable quality of life for a farmer or farm family. Important questions for future research are the extent to which farmers in the UK and Ireland endorse the dominant socio-technical imaginaries in both countries. Do Irish dairy farmers embrace the low cost grass based vision as it is described and do dairy farmers in the UK agree that systems do not determine outcomes but success depends on management? These questions have implications for the futures of the sectors and the extent to which farmers' views are represented in dominant imaginaries.

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## Appendix A Documents analysed

Country	Document
<b>Ireland</b>	
<b>Government</b>	<p>Climate Change Advisory Council (2018) <i>Annual Review 2018</i>. Dublin.</p> <p>DAFM (2010) <i>Food Harvest Food Harvest 2020: A vision for Irish agro-food and fisherie</i>. Department of Agriculture, Fisheries and Food. Dublin. Available at: <a href="https://www.agriculture.gov.ie/media/migration/agri-foodindustry/foodharvest2020/2020FoodHarvestEng240810.pdf">https://www.agriculture.gov.ie/media/migration/agri-foodindustry/foodharvest2020/2020FoodHarvestEng240810.pdf</a>.</p> <p>DAFM (2015) <i>Foodwise 2025: A 10 year vision for the Irish agri-food industry</i>. Dublin.</p> <p>Department of communication climate action and environment (2017) <i>National Mitigation Plan</i>. Dublin.</p> <p>Environmental Protection Agency (2012) <i>Consultation on Environmental Analysis of Food Harvest 2020 : Response of the Environmental Protection Agency</i>. Dublin.</p>
<b>Industry</b>	<p>AIB and IFA (2013) <i>Outlook: AIB's Series of Sectoral Research Reports Dairy</i>. Dublin.</p> <p>Hurley C and Murphy M (2015) <i>Building a Resilient, Flourishing, Internationally Competitive Dairy Industry in Ireland</i>. Dublin.</p> <p>IFA (2015a) <i>Farm Profitability Key to Agri-Food Growth: IFA Submission to Agri-Strategy 2025</i>. Dublin.</p> <p>IFA (2015b) <i>Towards a ' Milk Wise 2025 ' Strategy for Irish Produced Fresh Milk</i>. Dublin.</p> <p>IFA (n.d.) <i>Liquid Milk Handbook</i>. Dublin.</p> <p>Promar International Limited (2003) <i>Strategic Development Plan for the Irish Dairy Processing Sector</i>. London.</p>
<b>NGO</b>	<p>Environmental Pillar (2012) <i>Environmental Pillar Submission on the Environmental Analysis of Scenarios Related to Implementation of Recommendations in Food Harvest 2020 (FH2020)</i>. Dublin.</p> <p>Friends of the Irish Environment (2012) <i>Requirement for Assessment of Food Harvest 2020</i>. Cork.</p> <p>Irish Climate Justice (2012) <i>Irish Climate Justice Group Submission to the Department of Agriculture Public Consultation on Harvest 2020</i>. Dublin.</p>
<b>Research</b>	Boyle L, Marchewka J, Berry D, et al. (2017) ProWelCow – dairy cow welfare Authors.

	<p><i>TResearch</i> 12(3). Cork: 12–13.</p> <p>Delaney M (2015) <i>Sustainability – the Climate Change Challenge for Irish Dairying Farming Scholarships</i>. Thurles.</p> <p>Dillon E, Moran B and Donnellan T (2017) <i>Teagasc National Farm Survey 2016 Reults</i>. Athenry. Available at:  <a href="http://www.teagasc.ie/publications/2015/3596/TeagascNFSPrelimResults2014_final.pdf">http://www.teagasc.ie/publications/2015/3596/TeagascNFSPrelimResults2014_final.pdf</a>.</p> <p>Farrelly P, Crosse DS, O’Donoghue DP, et al. (2014) <i>Food Harvest 2020 - Environmental Analysis Report</i>. Dublin. Available at:  <a href="http://www.agriculture.gov.ie/media/migration/agri-foodindustry/agri-foodindustrypublications/2020Foodharvest190710.pdf">http://www.agriculture.gov.ie/media/migration/agri-foodindustry/agri-foodindustrypublications/2020Foodharvest190710.pdf</a>.</p> <p>Fitzgerald JB, Brereton AJ and Holden NM (2009) Assessment of the adaptation potential of grass-based dairy systems to climate change in Ireland – The maximised production scenario. <i>Agriculture and Forestry Meterology</i> 149: 244–255. DOI: 10.1016/j.agrformet.2008.08.006.</p> <p>Hennessy T, Buckley C and Dillon E (2013) <i>Measuring Farm Level Sustainability with the Teagasc National Farm Survey</i>. Athenry.</p> <p>Hennessy T, Moran B and Thorne F (2016) Why dairying? In: Teagasc (ed.) <i>Teagasc Dairy Manual</i>. Moorepark: Teagasc.</p> <p>Lyons Research Farm (2018) <i>Lyons System Research Herd Notes</i>. Dublin.</p> <p>Murphy P, Keena C, Hyde T, et al. (2016) Key Environment Issues Issues for Dairy Farmers Key Environment Issues. In: <i>Teagasc Dairy Manual</i>. Fermoy: Teagasc, pp. 163–174.</p> <p>O’Donoghue C, Creamer R, Crosson P, et al. (2015) <i>Drivers of agricultural land use change in Ireland to 2025</i>.</p> <p>Schulte RPO, Donnellan T, Black KG, et al. (2013) <i>Carbon-Neutrality as a horizon point for Irish Agriculture - A qualitative appraisal of potential pathways to 2050</i>. Oak Park.</p> <p>Thorne F, Gillespie PR, Donnellan T, et al. (2017) <i>The Competitiveness of Irish Agriculture. Allied Irish Banks and the Irish Farmers Journal</i>. Dublin.</p>
<b>UK</b>	
<b>Government</b>	<p>Defra (2012) <i>Progress towards a sustainable future for livestock farming</i>. London.</p> <p>Defra (2018a) <i>Clean Air Strategy 2018</i>. London.</p> <p>Defra (2018b) <i>Health and Harmony: the future for food, farming and the environment in a Green Brexit</i>. London.</p> <p>Expert Working Group on Sustainable Land Management (2016) <i>Delivering Our Future , Valuing Our Soils : A Sustainable Agricultural Land Management Strategy for Northern Ireland</i>. Belfast.</p>

	<p>FAWC (2009) <i>Farm Animal Welfare in Great Britain: Past, Present and Future. Farm Animal Welfare in Great Britain: Past, Present and Future</i>. London. DOI: 10.1016/j.rvsc.2007.04.021.</p> <p>FAWC (2010) <i>The welfare of dairy cows housed all year round and/or in very large herds</i>. London.</p> <p>National Assembly for Wales (2017) <i>Research Briefing: The dairy sector</i>. Cardiff.</p> <p>POST (2012) <i>Livestock Super Farms. POSTnote</i>. London. Available at: <a href="http://www.parliament.uk/business/publications/research/briefing-papers/POST-PN-404%5Cnpapers2://publication/uuid/76133D41-99B9-48FE-96CA-4DB6C6AA83AA">http://www.parliament.uk/business/publications/research/briefing-papers/POST-PN-404%5Cnpapers2://publication/uuid/76133D41-99B9-48FE-96CA-4DB6C6AA83AA</a>.</p> <p>Richardson A (2015) <i>A Review of the Dairy Sector in Wales</i>. Cardiff.</p> <p>Scottish Government (2013) <i>Scottish Dairy Review : "Ambition 2025 "</i>. Edinburgh.</p> <p>Scottish Government (2015) <i>Dairy Action Plan</i>. Edinburgh.</p>
<b>Industry</b>	<p>Agri-Food Strategy Board (2012) <i>Going for Growth: A strategic action plan in support of the Northern Ireland Agri-Food Industry</i>. Belfast.</p> <p>AHDB Dairy (2015) Evidence Report: GB herd performance 2014/15. (December): 9–11.</p> <p>AHDB Dairy (2017) <i>Delivering a more competitive industry through optimal dairy</i>. Stoneleigh.</p> <p>Andersons (2017) <i>Dairy Outlook 2017</i>. Melton Mowbray.</p> <p>CHAWG Dairy Cattle Welfare Subgroup (2018) <i>GB Dairy Cattle Welfare Strategy 2018-2020</i>. London.</p> <p>Dairy Roadmap (2015) <i>Dairy Roadmap 2015</i>. Dairy UK.</p> <p>Dairy UK (2017) <i>The white paper</i>. London.</p> <p>DairyCo (2013a) <i>Dairy statistics</i>. Kenilworth. Available at: <a href="http://www.dairyco.org.uk/non_umbraco/download.aspx?media=1438">http://www.dairyco.org.uk/non_umbraco/download.aspx?media=1438</a>.</p> <p>DairyCo (2013b) <i>Managing Costs: Key findings of the Milkbench+ dairy benchmarking programme regarding the efficiency of dairy production in the UK</i>. Kenilworth.</p> <p>DairyCo (2014) <i>Milkbench Evidence Report 2012/13</i>. Available at: <a href="http://dairy.ahdb.org.uk/resources-library/market-information/milkbenchplus/milkbenchplus-evidence-report-2014/#.VaJy__IVhBc">http://dairy.ahdb.org.uk/resources-library/market-information/milkbenchplus/milkbenchplus-evidence-report-2014/#.VaJy__IVhBc</a>.</p> <p>Dawson P, Lancaster B, Newberry R, et al. (2014) <i>Leading the way: The British Dairy Industry's Sustainable Growth Plan</i>. London. DOI: 10.1037/e515422010-040.</p> <p>NFU (2010a) <i>Dairy Cow Welfare Strategy. October</i>. Stoneleigh.</p> <p>NFU (2010b) Dairy farming systems in Great Britain. Available at: <a href="http://www.thedairysite.com/articles/2549/dairy-farming-systems-in-great-">http://www.thedairysite.com/articles/2549/dairy-farming-systems-in-great-</a></p>

	<p>britain/ (accessed 14 September 2016).</p> <p>NFU (2013) <i>Compete to Grow: A vision and strategy for the British Dairy Industry</i>. Kenilworth.</p> <p>The Dairy Group (2012) <i>Dairy Cow Housing Report prepared for Arla , Morrisons and DairyCo</i>. Taunton.</p>
<b>Research</b>	<p>Arnott G, Ferris CP and O’Connell NE (2017) Review: welfare of dairy cows in continuously housed and pasture-based production systems. <i>Animal</i> 11(2): 261–273. DOI: 10.1017/S1751731116001336.</p> <p>Davies G (2013) <i>Pasture Utilisation - Yield from the Field</i>. Taunton.</p> <p>Jackson A (2012) <i>Can we learn to love the megadairy? Politics, planning and PR</i>. Taunton.</p> <p>Levitt T (2018) <i>Put a label on it: why the future of milk is a branded one</i> Tom Levitt. Taunton.</p>
<b>NGO</b>	<p>Atkins (2011) <i>Application for Planning Permission for an Intensive Dairy Unit (Ref 10 / 1397 / FUL) at Nocton Heath , Lincolnshire Objection on Behalf of Compassion in World Farming and the World Society for the Protection of Animals</i>.</p> <p>CIWF (n.d.) <i>Report on the welfare of EU dairy cows</i>. Surrey.</p> <p>Compassion in World Farming (2011) <i>RE: Planning Application No. 10/1397/FUL   Erection of an intensive dairy unit North of Dunston Heath Lane and West of B1188 Nocton Heath Lincoln I</i>. Godalming.</p> <p>RSPCA (2017a) <i>Dairy cattle: to pasture or not to pasture ?</i> Horsham.</p> <p>RSPCA (2017b) <i>The Welfare of Dairy cows</i>. Horsham.</p> <p>Viva (2005) <i>The dark side of dairy</i>. Bristol.</p> <p>World Animal Protection (2016) <i>Full Fact Milk Making the right choices</i>. London.</p> <p>WSPA (2011) <i>Weighing up the economics of dairy farms: a briefing by the World Society for the Protection of Animals</i>.</p>