

## Article

# Conceptualising Disruptions in British Beef and Sheep Supply Chains during the COVID-19 Crisis

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**Abstract:** This paper explores the impacts of the COVID-19 crisis as a disruptor to Britain's beef and sheep supply chains. The assessment of COVID-19 impacts is based on the triangulation of farming and industry news reports, submissions to a government COVID-19 enquiry and interviews with industry experts. We find that livestock farming and farm services were least affected compared to processing, retailing, foodservice, or consumers. Primary and secondary processors continued to operate during the first COVID-19 lockdown but had to quickly become 'COVID secure'. The most dramatic effect was the overnight closure of hospitality and catering and the redirection of supplies to the retail sector. This picture of a resilient British beef and sheep industry may also be conceptualised as relatively locked in and resistant to change. Red meat production is tied to the land it farms on and operates on 12–36-month production cycles, making it difficult to change trajectory if disruptions do not directly affect farming. Emerging changes in agricultural payments, trade post-Brexit, and societal and environmental pressures may well be the disruptors that have far-reaching impacts on the beef and sheep supply chains.



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## 1. Introduction

The term food supply chain gives the impression of a linear system with one stage feeding into the next and so on [1]. However, the linear structure of supply chains sits within a complex web of interconnected organisations, individuals, and enterprises whose interdependencies and relationships form the food system, and also shape the functioning of those chains. This complexity can increase once trade and intertwining of global, as well as national or even local supply chains, are considered. The vulnerability of our food supply and the need for transformative change has been emphasised by multiple shocks and stressors that have impacted our food supply chains, such as climate change and this recent COVID-19 pandemic [1,2]. As the United Kingdom (UK) is the largest sheep meat producer and third largest beef meat producer in Europe [3], this paper focuses on an acute period within Britain (This analysis focuses on Britain, comprised of England, Scotland, and Wales and excludes Northern Ireland although government departments often serve the United Kingdom) during the full COVID-19 lockdown from March 2020 to June 2020 within the beef and sheep meat supply chains. This paper starts with the impacts on-farm and traces them through to consumption patterns.

England, Scotland, and Wales formally went into lockdown on 23 March 2020, although discussion about when and how to lockdown started before this. The public were ordered to only leave their homes for food, medicine, or exercise; however, the UK government made an exception for key workers who were granted critical worker status. Key

workers were regarded as essential to the running of the country and were performing work that could not be done from home. The category included healthcare workers, emergency response workers, sanitation workers, and, crucially, food and agricultural workers [4].

It was evident to the public that a lockdown was inevitable with widespread news coverage of consumers stockpiling food items. However, Kantar Worldpanel data suggested this was actually similar to a stocking-up behaviour, recording Christmas-type grocery shopping in the weeks leading up to the formal lockdown [5]. For Britain's food supply chains, it was the entire closure of the foodservice sector that created the biggest challenge, as is noted by the Farmers Unions [6], processors [7], wholesalers [8], and food researchers [9]. This created the acute challenge of redirecting the supplies from foodservice, which is noted to make up at least 30% of food purchases [9], into retail. The effect of the lockdown affected many supply chains, with images of empty supermarket shelves dominating news reporting. Although, it was noted that there were no actual food shortages: "food was always available in the broader supply chain, it was simply in the wrong place" [8]. The difficulty in redirecting supplies from foodservice to retail was also noted in other countries as well [10–12]. Disruptions were also noted in other supply chains including chicken meat [13], turkey, pork, and eggs [11].

In this paper, we ask what was the effect of the acute period of the lockdown on the British beef and sheep supply chains? We also ask which part of the supply chain was most affected? In doing so, this paper assesses the resilience of the beef and sheep supply chains in Britain—that is the extent to which they were able to absorb the perturbation of the pandemic and recover from the shock created during the first COVID-19 lockdown. Across disciplines, resilience often refers to the ability of an organisation or system to return to a stable state after a disruption [14]. In addition, drawing on theories of technological change, an alternative explanation of 'lock-in' [15] will be offered. Lock-in describes the inability of a system, organisation, or society to change the trajectory it is following and transition to a different one, often hoped to be a more sustainable trajectory [16].

In Section 2, we cover the literature on the beef and sheep supply chains, resilience, and lock-in. In Section 3, we explain the methods and data sources that provide evidence of the effects of the lockdown, as well as the approach for analysis. In Section 4, we look in turn at each part of the supply chain. In Section 5, we consider whether the British beef and sheep sectors are resilient to shocks similar to the COVID-19 pandemic, and whether they are locked-in or both. In this section, we also outline the longer-term changes in British agricultural policy and societal trends, which have the potential to cause change in the British agriculture and food supply chains.

## 2. Literature Review

British beef and sheep farming are important agricultural sectors contributing 16% and 6% of agricultural production, respectively [17], with millions of animals and thousands of farm holdings [18]. The British meat processing industry is dominated by six "mega-slaughterhouses" [19], p. 8, which process over 90,000 livestock units annually. For example, three of the largest abattoirs in Wales slaughter 95% of Welsh sheep [19].

These supply chains are characterised by low levels of trust [20] and imbalance in that the thousands of farms are routed through a steadily decreasing number of abattoirs and processing plants [19] and then through to a handful of large retailers (Tesco, Sainsburys, Asda, and Morrisons dominate UK meat sales with the Co-operative and Aldi competing for fifth place [21]) that both exert controls backwards on the supply chain [22–24]. As a result, British beef and sheep farmers are often described as 'price-takers' in that they have little control over the price they receive for their goods [17,25,26] British beef and sheep farmers, in particular, suffer from this unequal relationship with estimates of their dependence on agricultural subsidy to turn a profit ranging from 91–114% of their farm business income [17].

Moreover, farming incomes are noted to have declined since the reform of the Common Agricultural Policy, which changed the income support from payment per animal (headage

payments) to payment based on hectareage in agricultural production under the Basic Payment Scheme. The phasing out of the hectare-based Basic Payment scheme from 2021–2024 [27], is likely to affect the viability of many sheep and beef producers—even the most efficient and business-like enterprises [28].

British beef and sheep farming is no stranger to food crises, having been rocked by multiple food and farming scandals since the 1990s. In 1996, an outbreak of bovine spongiform encephalopathy (BSE) caused the death of 180,000 cattle with 4.4 million cattle culled on-farm in efforts to prevent further spread [29], as well as 178 deaths from a variant Creutzfeldt Jakobs Disease (vCJD), the human version of the prion disease [30]. UK exports of beef were badly impacted by the BSE crisis, “essentially putt[ing] the UK meat trade into quarantine” [31]; furthermore, UK beef was banned in the rest of the European Union from 1996 until 2006, with China only lifting its ban on UK beef and lamb imports in 2018 [30]. The economic costs to the UK industry from the BSE crisis were estimated to be around £4 billion [29,32]. A large outbreak of Foot and Mouth in 2001 likewise caused a mass culling of 4.2 million diseased animals and a further 2.3 million on welfare grounds [33] with an overall cost of £8 million [34]. This also traumatised the rural communities [35] and cost billions of pounds in lost tourism revenue [36]. Nonetheless, beef and sheep farming survived these losses with some farmers adapting by diversifying their businesses [33].

The other relevant crisis is the European-wide horsemeat scandal of 2013, which affected the beef supply chain at the point of processing rather than farming. Horsemeat was found by the Food Safety Authority of Ireland in a beef burger using DNA methods [37] and was discovered by the traceability systems set up in the wake of the BSE crisis [38]. This was described as a crisis of trust in complex food chains “vulnerable to subversion by criminal enterprises” [39]. The BSE and FMD crises were farming crises, while the horsemeat crisis was a trade and traceability crisis.

In terms of conceptualising beef and sheep systems, socio-ecological systems literature [40] is a way of understanding farming and other natural resource management as the intertwining of social and ecological systems and that ‘natural’ systems are often mediated by human actions [41]. Socio-ecological systems scholarship argues that ecological systems, such as land and environmental resources, are linked to social systems, such as land tenure and views on environmental resources [40]. This literature understands resilience as the quality of allowing a system to absorb perturbations without being substantially changed [42]. Even outside socio-ecological systems literature, the definition remains constant; in a systematic review of the concept across disciplines, the authors found:

The concept of resilience is closely related with the capability and ability of an element to return to a stable state after a disruption . . . Resilience is therefore related to both the individual and organisational responses to turbulence and discontinuities [14].

Recently, the Resilience of the UK Food System programme defined the concept as “the system’s capacity to deliver a desired set of outcomes when exposed to stresses and shocks” [43]. They also defined three aspects of resilience, which align with the above definition but also expands on it: robustness (ability to resist disruptions), recovery (ability to return to desired outcomes), and re-orientation (ability to accept alternative operations following disruption to maintain outputs).

Indeed, beef and sheep production systems are ecological systems of animals, land, and water, but which are mediated by social systems of farming, kinship, and property rights, as well as farming regulation, environmental regulation, animal health and welfare legislation, food legislation, agricultural subsidy, economic supply and demand, and many more. Whether the British beef and sheep supply chains absorbed the perturbation of “the biggest threat to UK food supplies since the Second World War” [44] will be considered in this paper.

However, critiques of the resilience in socio-ecological systems question the “resilience of what and for whom” [45] in that not all systems are beneficial and changing systems are sometimes needed. Oliver et al. [46] and Dornelles et al. [47] problematise resilience

in global food systems (of which supply chains are a part), dubbing it an “undesirable resilience” in that we have a climate crisis, and a health crisis and change is needed in global food systems.

Therefore, we will also consider whether the beef and sheep supply chains are locked-in and unable to change their existing trajectories. Lock-in, a concept from science, technology, and innovation studies, occurs when systems and organisations follow a technological path in such a way that it becomes difficult to adopt a new path [48]. The difficulty in changing paths leads a system or organisation onto that path:

One technology may become dominant over others that perform similar functions and compete for adoption by economic agents, even though it has inferior long-run potential. This ‘path dependent’ process is self-reinforcing and may lead to a technological ‘lock-in’ situation in which the dominant technology excludes competing and possibly superior technologies [49], p. 443.

An often-cited example in the literature on lock-in is the QWERTY keyboard, which was originally designed to slow down manual typewriters but still persists today on our computers and mobile devices.

Although innovation scholars (e.g., [50–52]) often write about nuts and bolts technology, the theories about lock-in and path dependency can be applied to environmental governance [53,54] or the socio-ecological systems of agriculture [55]. In Vanloqueren and Baret’s [49] review of the factors locking Belgian agriculture into high-yielding varieties of wheat, they identify market forces and agricultural policy as well as biological and ecological forces, such as yields of resistant varieties, unpredictability of epidemics, and incomplete resistance, as factors for locking out disease-resistant cultivars. The lock-in of the beef and sheep supply chains may be set by existing socio-ecological dependencies that are hard to change. These include the type of land used for livestock farming, livestock reproduction cycles, and farm business planning. The shock of COVID-19 is not the only one acting on food supply chains: the British departure from the European Union (EU); agricultural transition; changes in agricultural payments; trade deals; and climate change are all factors exerting pressure on British beef and sheep production systems. The present and future impacts of these other factors are not a focus of this particular study but are considered as part of the wider context of changes likely to affect the beef and sheep supply chains.

### 3. Methods and Analysis

#### 3.1. Data Sources

This paper uses three sources of evidence to triangulate the effect of the pandemic on the British beef and sheep supply chains: 1. Farming and food industry news reporting; 2. Written and oral evidence submitted to a UK Parliamentary enquiry [56]; 3. Interviews with stakeholders in livestock farming, processing, retailing, and foodservice. The farming and industry news that relates to beef and sheep farming and processing was monitored regularly from February 2020 to September 2020 for the acute impacts, and until October 2021 for longer term impacts. Sources include *Farmers Weekly* and *Farmers Guardian*, as well as mainstream news sources, such as BBC News.

The second source of data were written, and oral evidence submitted to a parliamentary enquiry. The Environment, Farming, and Rural Affairs Committee (EFRA), a cross-party Parliamentary Select Committee of the House of Commons that scrutinises the government department of the same name (DEFRA), opened an enquiry on the impact of COVID-19 on food supply in Britain on 19 March 2020, and published its first report on 30 July 2020 [57]. Farming organisations, industry organisations, processors, retailers, wholesalers, food businesses, and academics, as well as community organisations—such as those providing food parcels to vulnerable people—submitted evidence that is still publicly available at the time of writing. In total, 164 statements of written evidence were considered, as well as eight transcripts of oral evidence.

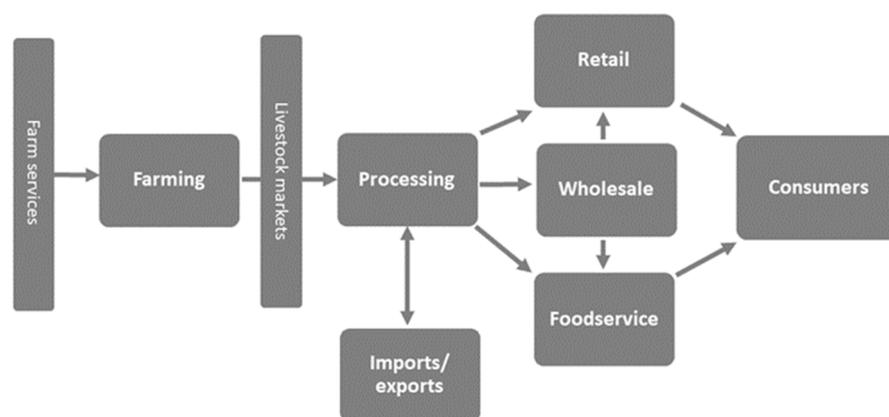
The third source of data were a series of semi-structured interviews with eleven British beef and sheep industry stakeholders from nine organisations conducted between November 2020 and July 2021 (More interviewees were sought, but some were too busy to respond, while others replied that they could not disclose the information even under the promise of anonymity). Interviewees included stakeholders from farming industry organisations, livestock organisations, levy bodies, meat processing, foodservice, and retailing. Three were membership organisations representing livestock farmers with thousands of members. Two other organisations were statutory levy bodies also with thousands of levy payers, likely with overlap with the farming organisations. Both types of organisations have insight into the rest of the supply chain as they liaise and campaign with them, as well as with the government. One interviewee represented a meat-processing membership organisation covering thousands of workers. This one represented abattoir, meat packers, independent butchers, and catering companies, as well as retailers, wholesalers, and foodservice. The interviewee from foodservice represented a large UK-based hospitality company with thousands of employees serving millions of customers from a range of meals each month. The large retailer had over a thousand outlets and over a hundred thousand employees. The medium-sized retailer had more outlets, but less square footage, and employees in the tens of thousands. Therefore, the interviewees all represented thousands of workers, businesses, and meat throughput with a comprehensive view of the effect of the pandemic on the beef and sheep supply chains. A different set of industry stakeholders would not have yielded different results. An anonymised list of interviewees is in Appendix A.

The interview questions asked the interviewees to recount the effects of the acute period (March–June 2020) of the pandemic, the following period of flux (summer 2020 to winter 2021), the more recent period if applicable, and any predictions for the future. The ethical approval for these interviews was granted in October 2020 by the University of Hertfordshire under protocol LMS/SF/UH/04287(1).

### 3.2. Approach to Analysis

All three data sources were analysed using a simplified red meat supply chain approach (see Figure 1) seen in supply chain studies [58,59] and food geography [60], which follows a food commodity through its sites of production and processing. For beef supply chains, cattle start on farms, which buy in some services such as veterinary care. After the farm, almost 85% of cattle [61] go straight to processing, with the remainder going through auction at in-person livestock markets. Processing includes slaughtering and butchering, while secondary processing includes meat packing, or turning carcasses into cuts with different specifications for different markets. Both of these stages are included under processing, as the companies that undertake slaughter also do meatpacking. There is a flow of beef products being both imported and exported, with domestic and imported products being delivered to processing facilities. From processing, different beef products go to retail, foodservice, and wholesale. Some products go from wholesale to retail and foodservice, but not to consumers; consumers purchase beef products from retail outlets and foodservice. Sheep supply chains are similar, although the most notable difference is that up to 50% of animals go through livestock markets [62] before processing—compared to only 15% of beef animals.

We describe the effects of the acute period of the pandemic on each part of the national supply chain, i.e., the effect on farming, followed by the effect on livestock markets and then followed by the effect on processing, and so on. This is what Braun and Clarke [63] describe as a topic summary approach, and can also be described as a template approach to qualitative analysis [64] by using the parts of the supply chain as a priori categories for analysis. The direct effects from COVID-19 infection are included in this paper, as are the effects of the mitigation measures of the lockdown.



**Figure 1.** Structure of GB beef and sheep value chains (source: authors).

Therefore, the impacts on farming and farming services were grouped together, likewise for livestock markets, processing, retailing, foodservice, wholesaling, and imports and exports. Many stakeholders were able to comment on their sector as well as the parts of the supply chain further up- or downstream.

#### 4. Results and Findings

This section describes the effect of the acute period of the pandemic on farming, farm services, processing, retailing, and consumer patterns in Great Britain. How did the red meat sector fare?

##### 4.1. Livestock Farming

Farming is not easily stopped and re-started as the National Farmers Union pointed out in its submission to the EFRA committee:

“Farming systems are biological in nature; they cannot be turned on and off in the way some other industrial processes can be. To rapidly “turn off” a livestock production system involves the culling of livestock, with the subsequent requirement to rebuild flocks and herds before supplies can resume.” [65], p. 2.

Indeed, beef and sheep farming continued with no reports of livestock culls carried by British farming news. Farming interviewees also confirmed that no beef or sheep animals were culled due to COVID-19 disruption. British dairy production, on the other hand, suffered wastage with around 1 million litres of milk discarded by 300 farmers who were unable to redirect highly perishable supplies from foodservice to retail [66].

In line with designating food industry workers as key workers, farm workers were also given this status. This made it easier for farmers to keep producing, although as farms are geographically dispersed and often family-run, i.e., already in a COVID-19 ‘bubble’, it is plausible many would have continued farming without key worker status.

When asked about the effect of the pandemic on the sector, one farming interviewee quipped “No one complains when prices are good!” [Farming industry organisation, interviewee 3]. Other farming interviewees also focused on price and demand:

“... we’ve seen good prices since that [initial disruption] all the way through the year.” [Farming industry organisation, interviewee 6]

“The impacts of COVID are positive in that the demand for British-produced, UK-produced beef has increased. The British consumers bought into British production, and I think that’s a positive for the industry.” [Farming industry organisation, interviewee 4]

The quote above from a member of a farming industry organisation suggests not only has the pandemic not been catastrophic, but its effect has actually been very positive. Multiple interviewees stated, with some embarrassment, that the overall effect was positive;

they were embarrassed because they were aware of the difficulties globally, but also because of the local and specific difficulties in other livestock sectors. Multiple interviewees compared the beef and sheep supply chains favourably to the chicken and pig meat supply chains:

*“With other livestock, with chickens or with pigs, if you have to wait a month, it creates huge problems. You could wait a week and it causes a problem. So you know with poultry, particularly broiler chickens, they go through that cycle, and when they’re ready, they’re ready. And these birds, because their growth rates are so quick they can go off their legs and you get welfare problems and pigs the same to some extent. Again you can hold [pigs] a little bit easier, but you don’t wanna be holding them for very long. You know, two to three weeks maximum really and they get too big very quickly and you get into stocking issues on farm.”* [Farming industry stakeholders, Interviewees 2 and 3]

With sheep and beef production there is flexibility in that if farmers need their animals to stop growing, they can be ‘stored’ over winter by feeding less and fattened the next spring by feeding more. Pigs have a rigid schedule where they take five to six months to fatten and, beyond that, continue to gain weight and fat, which makes them lose value at the abattoir as well as increasing the cost to the farmer for the continued need to feed them because they have not been transferred to an abattoir. Chickens are similarly rigid in their schedule, although are ready within six weeks. Furthermore, if both chicken and pigs are kept on-farm, this creates crowding for the next batch of animals born/hatched, which are similarly predictable.

An interviewee in meat processing commented that, in November 2020, there was an outstanding backlog of 50–60 thousand pigs held on-farm, gaining a kilogram a day, and that all the pig abattoirs had been working at maximum capacity since the acute period—being open six days a week to clear the backlog [processing stakeholder, interviewee 5]. This was before the Brexit transition officially started on 1 January 2021, and continued to be a crisis into December 2021, which was compounded by Brexit making imported labour movement difficult. A news item in October 2021 reported that small-scale welfare culls of piglets had started [67] concurrently with the granting of a temporary visa scheme for pork butchers, which had been introduced on 14 October [68].

The farm veterinary services were able to continue because veterinary staff were also designated key workers, particularly where they maintain the continuity of food supply or animal welfare [69]. This allowed the Animal and Plant Health Agency (APHA) to continue TB testing with social distancing in place, despite a call for a halt by the farming community [70]. Calves were made exempt from testing, as they were not able to be restrained and tested while maintaining a 2 m social distance. Not completing TB testing puts that farm under a movement restriction, in turn preventing the selling of those animals.

The British Veterinary Association noted however, that the focus on food supply and emergency animal welfare cases could cause a decline in herd health planning with long-term welfare and productivity implications [69]. Animal health planning is forward planning to manage the health and welfare of livestock with the ultimate goal of reducing the dependence on antibiotics and maximising productivity [71]. Commenting six months later, the farming interviewees were not concerned about herd and flock planning, mentioning that it moved online, and also that the period of disruption was short-lived, with one interviewee commenting that delays can be common in some parts of Britain:

**Interviewer:** *“So the delays in getting the longer term health and welfare done, you don’t think that’s going to have a lasting effect (trails off) . . . ”*

**Interviewee:** (With confidence) *“No, it was it was four, six weeks and you know that can happen in some places anyway. So no, there’s no long-term negativity from that.”* [Farming industry organisation, interviewee 4]

One category of farm staff that was not able to make it onto British farms were sheep shearers from Australia and New Zealand who usually visit to work in their off-season. Although international shearers were granted permission to enter Britain, Australia and

New Zealand had long travel bans to keep their COVID-19 rates low. In response to this risk, British wool and the National Association of Agricultural Contractors joined together to create a shearing register to map shearing need with ability. Interviewees commented that many sheep farming businesses just had to “*make do*” [Farming industry organisation, interviewee 6]. Another farming interviewee commented:

*“The season was quite favorable in terms of weather . . . Everything got shorn at the end of the day, so that’s positive. I’m sure there is couple of people that worked really, really hard to make that happen, but it did happen and so yeah. I don’t actually think there was any negative impact coming out of it.”* [Farming industry organisation, interviewee 3]

Although sheep fleeces were removed in a timely manner for the welfare of the animals, the market for sheep wool fell so low that some farmers were disposing of it on-farm rather than selling it at a loss [72]. Prices for sheep wool crashed to 32 p/kg—compared to 60 p/kg the year before [73]—due to the closure of export markets, particularly the Chinese market for wool, and only started showing improvement a year later [74]. Although the price was declining before the pandemic, it most certainly has exacerbated the fall.

Similarly, the bottom fell out of the market for ‘fifth quarter’ products—hides, offal, tallow, and tendons. International market closures also affected beef hides, particularly the closure of Italian tanning [75]. This caused the price of British hides to crash down to 40 p/kg by June 2020 from 80 p/kg in January 2020 [76]. Sheep skin had the same fate [76]. It was also reported that the value for other ‘fifth quarter’ products was low during the initial months of the pandemic [77].

Nonetheless, the overall assessment, based on interviewee comments and most farming news, was that the impact on beef and sheep farms has been overall positive, with prices and demand for meat increasing. Disruption of farm services was minimal, animal welfare impacts in the short-term were minimal, and long-term health planning is still operating. But beyond the farmgate, a farming industry interviewee described selling, processing, retailing, and foodservice as “*complete and utter, absolute pande-bloody-monium*” [Farming industry stakeholder, interviewee 7].

#### 4.2. Selling

To match the perceived ‘panic buying’ by home shoppers, there were also farmers ‘panic selling’ before lockdown, with the price of lamb dropping sharply by 23 March 2020 [78]. The overall result was lower lamb throughput for the month of March 2020 than March 2019 or March 2018 [79], and, by June 2020, lambs sent to slaughter had fallen by 22% and ewes by 40%. The latter, the level of ewe throughput, was a level the Agricultural and Horticultural Development Board (AHDB) had not seen since the Foot and Mouth outbreak in 2001 [80]. Although the price of lamb fell from 275 p/kg for liveweight lambs to just above 200 p/kg by the end of March, it recovered quickly and had been tracking about 25 p/kg higher than the 5-year average to December 2020 [81]. The Agriculture and Horticultural Development Board explained the reason for this in an interview with the BBC as a “*tightness in supply*” [82], and that there are fewer lambs available to be sold as farmers did not store them over the winter and sold them in 2019 due to Brexit anxiety. A processing interviewee confirmed that the volume of lambs sold during March–April 2020 was low enough that some lamb abattoirs closed for a few weeks.

The price of beef also crashed at the end of March, stayed low a little longer than lamb but quickly climbed from May, and has been higher than the 5-year average since June 2020 [83]. A trade press report in *Farmer’s Weekly* also attributed this to tight supplies as well as good weather in April and May, which increased the demand for beef burgers [84]. By April, beef throughput was down as well, which AHDB attributed to a number of factors: “*supply chain issues at abattoirs and auction markets, producers holding onto stock in the wake of uncertainty, and/or producers being busy on-farm with calving and spring planting*” [85]. By June, beef production had reduced by 4% [86].

#### 4.2.1. Livestock Markets

Some livestock markets around Britain temporarily shut in March 2020 after the lockdown was announced. This was short-lived and many re-opened days later and sought to continue trading by introducing social distancing and reducing the numbers of traders at the markets [87]. Breeding stock sales were also suspended throughout England and Wales in March 2020 to focus on getting animals into abattoirs, as opposed to onto other farms for reproduction [88]. To keep the sector moving, the livestock trading website SellMyLivestock waived fees for markets wishing to move their sales online during the crisis [89]. The Livestock Auctioneers' Association was also praised for working hard to keep the livestock markets open throughout the first lockdown [90]. The main change was that farmers could not watch their livestock being sold.

One farming industry interviewee commented on the importance of keeping the livestock markets open:

*"We've maintained that competition throughout COVID and that even when you do get localised issues where abattoirs are struggling because their throughputs are down because they've got people off sick, you know, people have always got the alternative of sending animals through livestock markets."* [Farming industry organisation, interviewee 2]

The above farming interviewee is stating that the live markets provided competition and flexibility for farmers to be able to continue selling their livestock. This has multiple benefits for farmers. Firstly, as the interviewee points out, it keeps an element of competition in an otherwise very consolidated market [19]. Secondly, this has benefits for animal welfare because the animals do not have to be shipped as far. Thirdly, more farmers can send their animals to slaughter 'within spec', or a certain stage of growth, musculature, and fat cover that the farmer receives an enhanced payment for the carcass. Lastly, it reduces the potential crowding on-farm, which is one of the welfare issues in the concurrent pig farming disruption.

#### 4.2.2. Processing

All staff in primary and secondary processing were also designated key workers as their work is key to maintaining food supplies. While it was fairly easy to create socially distant livestock markets, which are well-ventilated and barn-like, becoming 'COVID secure' was more challenging for abattoirs where staff "*stand shoulder-to-shoulder on a conveyor belt*" [Farming industry organisation, interviewee 2]. The measures meat processing companies had to implement included: extra personal protective equipment, the purchase of screens, handwashing stations, sanitising stations, marquees for staff to spread out on breaks, and more. An interviewee in meat processing said these changes took place over a period of a few weeks and that this was a cost that had to be absorbed by the meat processing companies, given that there was no short-term financial support provided by the government for this type of adaptation [Meat processing stakeholder, interviewee 5].

Despite implementing these changes at their own cost, there were disruptions in meat processing from March to June 2020 and beyond. This was not limited to Britain or to beef or sheep processing. COVID-19 outbreaks, rather than mitigation measures, caused the temporary closure of a beef abattoir in Scotland [91] and a beef processing plant in Ireland that supplies McDonalds [92], as well as facilities in other countries.

Sheep processing may not have made the news as, according to the meat processing interviewee, some sheep abattoirs shut during the period of March to May 2020 and furloughed their staff through the Government's Coronavirus Job Retention Scheme [93]. This period was while the price of sheep meat was down—as well as demand—and, along with an oversupply from panic selling before lockdown, demand dropped off due to the closure of EU foodservices [Meat processing stakeholder, interviewee 5], where a large volume of British sheep carcasses is exported.

Even where processors did not temporarily shut, some processors reduced the amount of meat they could produce [94]. Farmers Weekly reported that some facilities that would

have normally had eight production lines had reduced to two with social distancing and staff shortages. Some processors controversially responded to this reduction in capacity by buying supplies from abroad. ABP, one of Britain's largest beef processors, bought 400 tonnes of beef mince from Poland and packaged it under their regular packaging [94]. A retail stakeholder said he understood the commercial rationale for importing the mince: "you don't want empty shelves" [Retail stakeholder, interviewee 1].

#### 4.3. From Processing to Distribution

More disruptive than processors having to temporarily shut or import a small amount of mince was the overnight closure of the foodservice sector, which created multiple logistical problems throughout the supply. Farmers supplying direct to foodservice were also affected, with many noted by interviewees to have reinvented their business into direct sales of meat boxes. The closure of the foodservice sector was mentioned by the EFRA COVID-19 enquiry as a major issue by the National Sheep Association (NSA 2020), all the farming unions [6,65,95,96], and distributors such as the Association of Independent Meat Suppliers [97].

Closure of the foodservice sector created two problems: the first was the logistical problem of goods packaged for foodservice not being appropriate for retail. Although a derogation was granted on packaging allowing wholesale and foodservice goods to be sold in supermarkets [44], few homebuyers are in a position to buy wholesale products (For example, wholesale flour in 16 kg and 25 kg bags was widely available in the flour supply chain when the supermarkets shelves were empty [98]).

Secondly, this created an issue of carcass imbalance, as the beef and sheep products consumed outside of the home differ from those consumed at home. Carcass balance is the process of finding markets for as many parts of an animal as possible and getting the best value possible. It is the responsibility of meat processors to seek markets for undesirable or low-value cuts, as well as fifth quarter products of offal, skins, and hides. A processor may supply restaurants with high-value cuts, as well as different cuts or products to the retail, wholesale, or export markets. As high-value steak and lamb shoulder are often eaten out of the home in Britain, they were not shifting out of processing plants in March 2020 and were piling up in cold storage [7]. To stop products in cold storage from going out of date, there were multiple solutions. The first was freezing some food items. This was not a preferred solution as it can take 30% off the retail value and storage fees have to be paid, resulting in up to a 35–40% loss over selling chilled [Meat processing stakeholder, interviewee 5].

The second was mincing the high-value steak that no longer had a destination in foodservice. The meat processing interviewee said this was the actual reason for importing the controversial Polish beef mince, given that processors were "mincing high-value sirloin, lost a small fortune" [Meat processing stakeholder, interviewee 5]. The third solution was coordinated efforts to balance the carcass away from mince and sell the high-value cuts to the home buyer [6,65,99]. A farming industry organisation that engages with retailers recounted writing to them saying:

*"We believe you've got a moral imperative to do more to promote product. This is our only route to market'. And they did to be honest with you, British retail really did step up and you know, every one of them, even the likes of Asda . . . were really, really putting on big promotions which would cost them money."* [Farming industry stakeholder, interviewee 3]

This resulted in campaigns in-store to promote higher-value cuts and to encourage the home buyer to consider spending £7 instead of £5 on steak, when they might have otherwise spent £10–15 if they had been able to eat out in a restaurant.

The Association of Independent Meat Suppliers also reported that many of their members were working hard to redirect their supplies into retail and directly to home buyers [100] with wholesale butchers and farmers starting meat 'box' schemes.

#### 4.4. Foodservice

Although other food workers were made key workers, foodservice was shut down from March to June 2020—except for a few restaurants attached to hotels that housed key workers and vulnerable people. These foodservice workers were eligible for furlough schemes with up to 29 thousand out of 35 thousand employees of one foodservice business on furlough. However, the food supplies in cafes, restaurants, takeaways, warehouses, and in the abattoirs on their way to their warehouses still had to be redirected:

*“We’ve got food that’s in process at the factory that we no longer need. Got food in our depot that we no longer need that is perishable. And then we’ve got food at each individual restaurant that they have to throw away as well.”* [Foodservice stakeholder, interviewee 1]

The foodservice interviewee said that they solved redirecting the food that was already in their restaurants by gifting it to their employees, and the food that was in their warehouses was donated to food redistribution charities. He was unable to comment on whether the food products in the processing factories were able to be redirected, but, on those parts of his business where he does have oversight, thought there had been a significant but unknown amount of all types of foods wasted. At the time of interview (November 2020), months after the full lockdown, the British foodservice sector had not completely reopened at its full capacity and the foodservice interviewee’s depots were still full of foodstuffs at risk of going out of date.

On the challenge of getting foodservice products into retail, one farming industry stakeholder discussed this with a supplier for McDonalds:

*“I said to one of the guys ‘So you shut down McDonald Burgers. So why can’t you repackage McDonald Burgers and put them into the supermarket?’ And there’s two simple answers to that. One, is that it’s not a supermarket specification burger and two, the way of distributing McDonald Burgers in cardboard boxes with 100 or more. Not in four-pack of vacuum packed products. So you can’t change that burger line into a supermarket retail burger line.”* [Farming industry stakeholder, interviewee 7]

Each retailer and foodservice outlet has its own ‘recipe’ for different cuts they sell [23], so burgers destined for McDonald’s are at a size and composition to meet the product specification agreed to in order to supply McDonald’s, and therefore will not meet the specification for Tesco, Sainsburys, Waitrose, and so on. Even if retailers were willing to redistribute McDonald’s burgers (a labelling derogation was granted to allow this to happen), foodservice and wholesale packaging are not appropriate for the home cook. This happened with multiple food commodities, including flour, which is normally sold to processors in 16 kg and 25 kg bags [98].

It was these hurdles, the differences in retail versus foodservice specification and retail versus wholesale packaging, that a farm industry stakeholder interviewee gave as another reason for the imported Polish beef mince:

*“You might recall there was a whole bloody ballyhoo about Polish beef mince being on the shelves in the supermarkets . . . but what happened was the supermarkets suddenly faced a massive demand for mince. Needed to get it on the shelf from somewhere. Supply chain couldn’t change quickly enough.”* [Farm industry stakeholder, interviewee 7]

#### 4.5. Retail

Supermarkets remained open with their workers classified as key workers. Like food processing, they also had to quickly become COVID secure with increased cleaning, masks for staff and shoppers, hand and trolley sanitiser, and other measures. Retailers also found their online shopping increased substantially with online delivery ‘slots’ booked up two to three weeks in advance. By September 2020, retailers started hiring more staff to fulfill the increase in online orders [101], and other retailers started partnering with delivery companies such as Deliveroo [Retail stakeholder, interviewee 11].

Interactions between processing and retailing have been mentioned already, with retailers running promotional campaigns to shift higher-value cuts. What has not been mentioned is that consumer patterns changed, with multiple interviewees referring to “recessionary buying patterns” [Farming industry stakeholder, interviewee 3]. Home shoppers early on in the first lockdown increased their consumption of low-value mince, with beef mince purchases increasing by 45% [102]. It was this spike in demand for beef mince that could not be replaced by the domestic foodservice supplies that led to importing Polish beef mince and running promotional campaigns.

Retailing of lamb was not as impacted as it is European foodservice that sells a large proportion of British lamb. Nonetheless, there were some changes in patterns. Lamb roasts, which are usually popular for the holidays of Easter and Ramadan, were down across Britain due to households being unable to mix for any reason during the first lockdown [103]. However, retail sales of lamb chops rose by almost a quarter, with individual lamb customers increasing by 1.5% [103]. Unlike beef, this did not unbalance the carcass. This was followed by a summer retail campaign similar to the one for beef, although it was launched to increase demand during an unpredictable period of the pandemic when lamb production was also reaching its annual peak [104].

One farming industry interviewee identified a silver lining of the issues with rebalancing the carcass; he said that as a result of discussions with retailers on how to solve the issue, he had developed a close working relationship with a supply chain director at a major retailer:

*“What was borne out of that is I have a very good relationship with [named buyer] from [major retailer]. [Major retailer] recently committed when they were bought out with their new owners that they will source and supply to their customers only British beef. So that’s also come out of the pandemic, and you know there was a bit of a PR own goal.”* [Farming industry stakeholder, interviewee 4]

The above interviewee (as well as others) commented that this particular retailer had historically purchased low levels of British beef.

#### 4.6. Imports/Exports

Britain has historically had high levels of self-sufficiency in beef and sheep meat and 2020 was no different at 85% and 110%, respectively [105]. However, imports and exports are still important, as British consumers do not eat either animal nose to tail, and Britain imports beef steak [23] and lamb legs [106] to meet demand. Although there were bureaucratic issues to overcome, like difficulties in obtaining documentation on sanitary and phytosanitary (SPS) certification at ports [107], Defra, in March 2020, noted that the supply lines in and out of Europe remained open and functioning [108]. It was these functioning supply lines that allowed the importing of the beef mince from Poland to meet demand from the home shopper.

Despite supply lines remaining open, AHDB reported that British imports and exports of beef were down 15% in April [109], and that at an EU-level, the pandemic had driven down usage of beef quotas [110]. Imports of beef were forecast in July to remain low due to a continued overall reduction in demand, and that exports of beef were expected to fall by 2% due to lower farm-level production [85]. Exports of sheep meat fell 40% in March, partly due to France closing its foodservice sector the week before Britain entered its lockdown [111]. Conversely, sheep meat imports increased by 16% in March, largely due to shipping from New Zealand and Australia in February because they had issues shipping to China [111]. However, shipments from Australia and New Zealand dropped after this, with overall imports down by 9% for January to May 2020 compared to the previous year [112]. This has been attributed to multiple reasons including a drop in prices and demand due to COVID-19 disruption [113] as well as worldwide closure of foodservice businesses [114] and issues in long distance sea shipping [115].

#### 4.7. Direct Sales

Many actors across the food commodity supply chain expanded or started new box schemes directed at consumers [116]. Interviewees could recall examples where farms that supplied local pubs and restaurants doubled their online sales. One butcher in the Midlands of England is reported to have increased its online sales by an order of magnitude:

*“A butcher in [the East Midlands] started an online service last April. His April 2019 sales were £600. His April 2020 sales were £41,000. Now, that’s not all beef, that’s everything that you can get from a butcher, which is almost everything now, but it’s just the difference. So anyone being pressurised from closed pubs and restaurants and stuff were able to create new markets.”* [Farming industry stakeholder, interviewee 4]

What is unknown is how long such change will endure. A retail interviewee commented that it was difficult to know if such changes were the effect of the pandemic or the general trend. Anecdotal evidence from a small meat box supplier is that demand for their boxes increased four to five times in a very short timeframe in March 2020, and is now around three times pre-pandemic levels, but they are also not sure if it is the effect of the pandemic or the general trend (Personal communication, 26 October 2021).

Summaries of all the impacts and the amount of disruption are summarised in Tables 1 and 2. The criterion for assessment is a qualitative comparison of the interviewees’ comments on the extent of the disruption. The interviewees commented that beef and sheep farming was not too badly affected compared to processing, which had to quickly become COVID-secure at their own expense, but which was not as badly affected as foodservice—which was almost completely shut down for months.

**Table 1.** Summary of COVID-19 Beef Supply Chain Impacts.

Part of Supply Chain	Impact	Disruption
Farming Services	Herd health planning online TB testing suspended for calves	Minimal
Farming	No culling Farmgate price up Held animals on farm	Minimal
Processing	Became COVID secure Reduced production lines Imported Polish beef mince	Medium
Imports/Exports	Both down	Minimal
Foodservice	Almost completely shut	Major
Wholesale	Became COVID secure Involved in redirection	Medium
Retail	Became COVID secure Sales up and involved in redirection from foodservice Ran promotional campaigns	Medium
Consumption	Increase in beef mince purchase	Medium

Note: Minimal = almost functioning normally; Medium = functioning with some disruption; Major = not functioning.

**Table 2.** Summary of COVID-19 Sheep Supply Chain Impacts.

Part of Supply Chain	Impact	Disruption
Farming Services	Flock health planning online Shortage of sheep shearers	Medium
Farming	No culling Farmgate price up Held animals on farm	Minimal
Livestock markets	Became COVID secure Short-term panic selling Suspended sales of breeding stock	Minimal
Processing	Became COVID secure Reduced production lines Temporary closure of abattoirs	Medium
Imports/Exports	Both down	Minimal
Foodservice	Almost completely shut	Major
Wholesale	Became COVID secure Involved in redirection	Medium
Retail	Became COVID secure Sales up and involved in redirection from foodservice	Medium
Consumption	Decreased lamb roasts, off-set by lambchop sales	Minimal

Note: Minimal = almost functioning normally; Medium = functioning with some disruption; Major = not functioning.

## 5. Discussion

Going back to the question posed by this paper, the effect of the first lockdown on the beef and sheep supply chains in Britain was, on balance, positive. Interviewees cited the high farmgate price of beef and sheep, high consumer demand for beef, and consumer interest in British red meat. Interviewees praised the livestock markets for remaining open and the processors for keeping product on the shelves:

*“The livestock markets have remained open . . . [Processors] actually kept product on the shelves. And our farmgate prices remained, so the resilience of the supply chain has been pretty remarkable really.”* [Farming industry stakeholder, Interviewee 3]

As we can see from the above interviewee’s quote, the beef and sheep sectors are understood by the industry as resilient to shocks, such as those of the nature of the recent COVID-19 pandemic. This was a very different experience than either the BSE or FMD crises, and also different in nature to the horsegate scandal, as there was no fraud involved.

The second question (Which part of the supply was affected most?) is addressed in Tables 1 and 2, which identify that foodservice was most affected by the government-mandated shutdown. However, even in the face of disruption caused by the foodservice closure and reduced labour in processing plants, the British beef and sheep supply chains absorbed the perturbation of the acute period of the COVID-19 crisis, when compared to the chicken and pork supply chains. British beef and sheep supply chains reorganised themselves and adapted within a few weeks. More than this, they benefitted from the perturbation in that farmgate carcass prices rose [61,62], consumer demand increased, and consumer opinion of British produce rose. The beef and sheep supply chains were able to adapt, more than chicken and pork, due to the flexible nature of beef and sheep farming and due to farmers being able to hold animals on-farm for a few extra weeks or months. The “just in time” system of chicken production is noted by Chapot et al. [13] to remove redundancy and allows streamlining, but it has left itself vulnerable worldwide [13].

This result of the British beef supply chains is similar, yet different, from the experience of the Canadian and American beef industries, which also needed to redirect supplies from

foodservice into retail [12,117], but which had more widespread and complete shutdowns of meatpacking plants. Beef slaughter facilities were reduced by a third in the US and 60% in Canada [12]. This caused wholesale beef prices to double in Canada. However, Rude [12], writing a year later than Martinez [117], reported that the Canadian beef sector had returned to near normal a year from the start of the pandemic emergency. The Canadian pork industry, which was similarly disrupted, was also described as resilient [118]. The Canadian pork industry remained flexible through shipping live animals interprovincially and into the US [118] to manage processor shutdowns, which was an option that was not available to British pig farming.

With critiques of resilience in mind and questions of “resilience of what and for whom” [45], we can recast the resilience of the British beef and sheep supply chains. What should be considered here is that the benefits, i.e., the increase in prices, refer to the meat carcass only, and, when considering the animal as a whole, the narrative is different. With no market for wool, hides, skins, or other fifth quarter products, we cannot describe the beef and sheep sectors as completely resilient. In addition to the hides and skins, processors will also seek to sell offal, tendons, tallow and more into the pet food, fertiliser, and energy generation markets [119]. If the bottom falls out of these markets, there is a risk they are not used and are disposed of. Put in the context of climate change and societal pressure to reduce greenhouse gas emissions, waste of the fifth quarter is doubly unacceptable.

Although our food systems do many things well, critics have noted for many years its many negative externalities, i.e., the negative consequences that result but are not included in economic analyses, such as pest and disease outbreaks due to monoculture plantations [120,121], ecological and social harm [122], regional and income inequalities [123], and more. Despite the growing dissatisfaction with modern food systems, transformation is slow with a number of “mechanisms that ‘lock-in’ food systems in unsustainable states” [46], p. 1. Therefore, another way of understanding the beef and sheep supply chains in Britain is as locked in, i.e., locked into production, locked into processing, and locked into supply chain relationships and the relative dominance of corporate retailing. Arguably, consumers are not as locked into beef and sheep meat consumption as it has reduced from around 300 g of beef per person per week and 139 g of sheep meat per person per week in 1975 to 130 g of beef and 37 g of sheep meat per person per week in 2018, having been largely displaced by chicken and pork [124].

The socio-ecological system of beef and sheep farms lock in farmers in multiple ways. The production cycle of beef is approximately 36 months from the reproduction process to slaughter, so, in March 2020, those farmers with saleable beef cattle were already three years invested in those animals. The production cycle of lamb is shorter at around a year from reproduction to slaughter. Regardless, many types of farmers plan their businesses in years rather than months. Given this, a disruption of a few weeks or a few months may not be enough to seriously alter the current practices and trajectories of beef and sheep farming in Britain. Brexit, which has been years in the making, has caused farmers to make changes to their business, with some sheep farmers thought to have already reduced their flock size in anticipation of not securing a trade deal with the European Union [125]. Even though a European trade deal has been agreed, the national flock will take time to rebuild. Current controversial trade deals with Australia and New Zealand, and subsequent deals with the rest of the world, may also cause change in British farming as there are widely held concerns in the industry about cheaper products produced with lower animal welfare standards undercutting British produce [126].

Another element of the socio-ecological system of the farm that may lock farmers into their current business is their actual land. Beef and sheep farming mostly occurs in Britain in less fertile locations [127,128] with arable farming in the more fertile locations. Hill farmers—sheep farmers in hilly locations—rear sheep as it is an economic activity that can occur in rural, mountainous areas with poor topsoil. Other economic activities that can occur in the same locations include on-farm diversification, such as wind power generation or tourism. However, to be paid an agricultural subsidy under the Basic

Payment Scheme, land must be in agricultural production [129]. Agricultural payments in Britain are transitioning from hectare-based payments to “public money for public goods” [130] under the post-Brexit agricultural transition plan. This means farmers may be paid to be land managers [131], with payments available for those activities that produce designated public goods. In a situation where agricultural subsidy is not available for the land supporting beef and sheep production, but is available for carbon sequestration—or other payments for ecosystem services—hill farmers may make different choices.

Additionally, the pressure to reduce greenhouse gas emissions is a pressure of which farmers are aware. Pressure to reduce red meat consumption can be seen in many areas, including the UK’s Climate Change Committee, who recommend reducing beef and lamb consumption by 20% in 2020 [132]. More recently, in August 2021, Henry Dimbleby completed the National Food Strategy for England, an independent report commissioned by the UK government on how to meet the two challenges of environmental sustainability and rising obesity rates. One high-level recommendation was to reduce meat consumption by 30%, in addition to reducing high-fat, high-sugar foods, and increasing fruit and vegetable consumption and consumption of dietary fibre [133]. The National Sheep Association issued a statement in response, questioning the 30% reduction target and the actual contribution of British ruminant methane emissions, given many are fed on carbon sink pastures [134]. On the demand side, meat consumption has been declining since the 1970s [124]. The continued bad press about the emissions of red meat production, combined with future payments and trade deals, may drive beef and sheep farmers out of the industry.

## 6. Conclusions

In the acute period of March to June 2020, neither beef nor sheep farming in Britain needed to cull animals on-farm for health or welfare reasons that arose from the restrictions placed during lockdown. Farming operations continued, with COVID-19 infections on farms not featuring highly in interviews or news coverage. Veterinary services continued, in-person in the case of emergencies and animal welfare and via video call for longer-term health planning. Sheep shearing continued without Australian and New Zealand labour but with on-farm and local labour instead and was helped by good weather extending the season. More sheep than beef farms held their animals on-farm for a few weeks longer than normal while waiting for the markets and processors to calm down, which chicken and pig farmers were not able to do without animal welfare issues. At the time of writing in December 2021, the British pork supply chains were still in crisis and beef and sheep were not.

The livestock markets experienced panic selling before lockdown and the crash of prices for beef and sheep. After lockdown, they only shut for a few days before reopening with social distancing in place and livestock prices steadily rose to their original price and then beyond. Apart from social distancing and suspending the selling of breeding stock for a few weeks, livestock markets were not substantially disrupted.

Primary and secondary processors were disrupted by COVID-19 mitigations as well as COVID-19 infections closing a few beef processors for a period of self-isolation. A number of sheep abattoirs shut temporarily due to the British throughput being down and a drop-off in demand from the EU foodservice. Mitigation measures decreased the number of processing lines able to be open, decreasing the amount of meat products able to be produced.

The closure of foodservice was the most serious disruption, with thousands of employees on furlough. The disruption to the food supply chains was attempting to redirect foodstuffs already in processing, storage, and in foodservice outlets. It was the redirecting of foodservice beef in processing that was partly responsible for the decision to controversially import Polish beef mince. In addition to processing lines being reduced, beef carcasses with high-value steaks were being processed into £4 p/kilo mince.

Retail also had to become COVID-19 secure but was not plagued with site shutdowns from infections. Retail was able to absorb the beef and sheep products in primary process-

ing, where it had not been butchered to a specific foodservice specification but where it also met their other specifications (e.g., welfare, traceability, and origin). Moreover, retail coordinated with the rest of the beef and sheep supply chain to run promotional campaigns to shift the home shopper to buy more expensive cuts of meat instead of mince.

Consumer trends during the acute period included recessionary purchasing of beef mince and is the final reason for the importing of Polish products. Consumer demand for mince outstripped our domestic supply of beef because production lines were reduced. Additionally, what lines were operating were mincing high-value beef carcasses that would have supplied foodservice. Rather than have empty shelves, which is not common in retailing in normal times and would increase panic buying in panicked times, Polish mince was imported by a processor and packaged in the retailer's normal packaging.

The short shock of the first lockdown of the pandemic was not enough to seriously disrupt the beef and sheep supply chains in Britain. Consequently, British beef and sheep farming is viewed by the industry as relatively resilient compared to other meat production systems more reliant on just-in-time cycles.

However, there are mitigations we can take to avoid this disruption for future pandemics, as well as while this pandemic continues to wear on. The first is not shutting down part of the supply chain, as it was this that caused the most disruption and the need to redirect supplies. Indeed, in the months after the first lockdown, Britain has had subsequent waves of infection and lockdowns, but has not completely shut down foodservice. It has continued to operate with restrictions in place, but has not been shut down to the same extent as between March 2020–June 2020. Secondly, even though red meat is a source of greenhouse gas emissions, beef and sheep-producing economies should keep some amount of production for its flexibility in the face of shocks. Thirdly, chicken and pork industries should introduce flexibility back into their supply chains so that they are better able to weather future storms.

A limitation of this paper is that it focused specifically on British farming, which has a different economic and ecological make-up than beef and sheep farming in other countries, so the results may not be generalisable. Future research should continue to monitor the effect of the pandemic on farming supply chains. As the pandemic continues to wear on, the uncertainty may result in reduced flock or herd size, a response the British beef and sheep supply chains have already taken in response to the uncertainty of Brexit. Similarly, the longer-term trends of changing agricultural payments, trade deals, and societal pressure may also reduce the size of the British herd and flock. This will break British beef and sheep out of lock-in, as the social-ecological context shifts, and supply chains are reshaped by these pressures. However, it is difficult to untangle these effects from the uncertainty of the pandemic.

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## Appendix A

**Table A1.** Anonymised list of interviewees.

Interviewee Number	Type of Organisations	Date
1	Large, GB-based foodservice company	27 November 2020
2	GB farming industry organisation A	3 December 2020
3	GB farming industry organisation A	3 December 2020
4	GB farming industry organisation B	3 December 2020
5	GB industry organisation	7 December 2020
6	GB farming industry organisation C	8 December 2020
7	GB statutory levy body A	11 January 2021
8	Large GB retailer	28 January 2021
2	GB farming industry organisation A *	7 January 2021
3	GB farming industry organisation A *	7 January 2021
9	GB statutory levy body B	18 February 2021
10	GB statutory levy body B	18 February 2021
11	Medium GB retailer	20 July 2021

\* Interview continued.

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