Extended Abstract

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Paper Title	The consequential carbon burden of animal disease outbreaks

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Abstract	*200 words max*
Livestock production is under particular scrutiny for its impact on GHG emissions. Animal disease outbreaks will impose direct costs on producers and additionally trigger indirect economic effects on the livestock sector as a result of shifts in consumption across commodities. This shift in demand for meat products will also positively or negatively affect carbon emissions. We employ a vector error correction model to capture the dynamic market impact of disease outbreaks on livestock production and the subsequent changes in GHG emissions from consumption switching in these markets. Four animal diseases are considered: African swine fever, sheep pox, bluetongue virus, and foot and mouth disease. The indirect costs are quantified under different severities of outbreak by estimating the changes in revenues in the main livestock market affected by the disease as well as related livestock and feed markets. By associating the subsequent consumption switching with emissions factors, we identify the consequential carbon impact of livestock disease. The indirect costs of all animal diseases considered individually range from £1 million and £53 million, whilst the net reduction from meat supply and consumption in GHG emissions ranged between 0.005 and 0.67 million tonnes of CO_2e, which valued between £0.4 million and £44 million. This opens a debate over the role of government compensation schemes for disease outbreaks and argues for holistic approaches between targets for net zero compared to support for sustaining and restructuring livestock sectors.	

Keywords	Economic impact assessment – climate change – time series analysis – animal health
JEL Code	Q Agricultural and Natural Resource Economics; Environmental and Ecological Economics see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	*100 – 250 words*
Livestock is a key source of GHG emissions that lead to global warming. Animal diseases and poor animal health exacerbate this problem by increasing emissions from livestock. The mechanism in which animal diseases increase emissions is through biological and production inefficiency. Beyond the farm gate, animal disease also disrupts downstream meat markets by shifting the consumption patterns towards cheaper alternative meat products in response to reduced production and increased prices of affected meat products. This consumption shifts between different meat	

markets will also impact overall GHG emissions from the livestock sector. So far, no studies have been conducted which link these indirect economic market effects with climatic consequences. Those few studies which have looked at the climate consequences of animal disease outbreaks have only focused on the direct effect of deteriorated animal health on GHG emissions. Our study fills this gap by assessing the consequential economic and carbon impacts of four economically important diseases. This offers an extension to the current literature and widens discussions on the greenhouse gas burden of livestock disease.

Methodology	***100 – 250 words***

A disease outbreak is expected to disrupt livestock markets by decreasing the domestic supply of the infected livestock products and increasing the supply of substitute products. Consequently, prices would also change to achieve market equilibrium between supply and demand of affected products.

We fitted a time series (vector error correction) model to historical data to predict the magnitude of change in market prices and quantities. Based on these predictions, changes in market revenues due to a disease outbreak could then be estimated which we defined in our analysis as “indirect economic costs”. Our time series model has been developed through three main stages: collection of time series data, determining the suitable specification of our time series model, and estimating the indirect economic effects.

Changes in GHG emissions due to a disease outbreak are quantified by estimating the changes in the supply of all modelled commodities and then multiply these changes by emissions intensity factors, where the emissions intensity factors represent the amount of GHG emitted per kg of meat. To value the emissions from changes in market supply, we multiply the estimated changes in GHG by a carbon price. We use the UK ETS price for non-traded sectors to value the change in GHG emissions.

Results	***100 – 250 words***

The indirect costs of all animal diseases, which were considered individually, were estimated approximately between £1 – £53 million. Foot and mouth disease led to the largest adverse impacts among all the diseases considered in our analysis which was estimated to range between £4 and £53 million, while African swine fever led to the smallest impact estimated between £1 – £6.9 million.

Depending on the disease and size of the outbreak, all modelled diseases led to net reduction in GHG emissions ranging between 5 – 668 thousand tonnes CO_2e, which were valued between £0.3 – £44 million using the Emissions Trading System (ETS) price of the UK. A foot and mouth disease outbreak has the largest reduction in GHG emissions which was valued between £6 – £44 million, while African swine fever has the smallest reduction in GHG emissions, which was valued between £0.4 – £2.5 million.

Discussion and Conclusion	***100 – 250 words***

Climate and biosecurity policies are highly interconnected. An animal biosecurity policy that maintains a healthy livestock population can minimise the animal health component of the net zero aims. This could be achieved by establishing robust surveillance systems for animal health as well as increased monitoring and prevention within domestic production. This requires mobilisation of effort and increasing scarce public resources, however if the GHG burden were included in assessments of animal health surveillance, this would provide a more compelling argument for intervention by public and industry actors.

We argue that a compensation payment that accounts for GHG impacts of restocking should be considered. Presently, for some diseases, a mandatory partial or full cull of animals may be needed and compensation for restocking should incentivise replacement with higher yielding breeds, or in some cases multi-use cattle, such as Norwegian Red. This challenges current farming systems but offers a transition to more regenerative and climate smart approaches expected from new agricultural payment regimes in the UK.

Compensating livestock farmers to be able to restock and recover from an animal disease outbreak is essential to restore lost incomes, employment, and minimise adverse economic consequences on closely related sectors and the wide economy. However, ensuring a holistic approach by the government between targets for net zero and support for sustaining and restructuring livestock sectors paves the way towards a more resilient and carbon-neutral livestock sector.