Title: Welfare Analysis of Livestock Disease Outbreaks,

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Welfare Analysis of Livestock Disease Outbreaks

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Introduction

Emerging and re-emerging foreign animal and zoonotic diseases have gained exposure due, in part, to risk in production and trade (Pendell et al., 2015). The economic importance of livestock disease impacts tends to be inexact, and in many cases the costs have not been measured in a systematic quantitative manner.

Bovine spongiform encephalopathy (BSE) a.k.a mad cow, Rift Valley fever (RVF), and highly pathogenic avian influenza (HPAI) rank as some of the high impact zoonotic diseases [$20-$200B losses worldwide, WB (2010)].

Commonly, impact analysis and quantification rely on point estimates from selected scenarios. This overlooks the stochastic nature of a shock, while not accounting for either the full range of the parameter support space or higher moments.

A more systematic approach quantifying disease shocks may provide insights over the distribution of disease outcomes, how differently the shocks impact the economy, and how to more efficiently allocate resources and to identify indemnification across affected economic agents.

Objectives

Our interest is in understanding the distribution of economic outcomes and welfare changes across livestock diseases outbreaks in a multi-markets structural model setting.

Contributions and specific objectives are:

- Use structural economic modeling with a Bayesian approach to generate a full posterior distribution of outcomes of an outbreak given the prior knowledge of disease shocks.
- Inform Bayesian priors on key parameters using information from a thorough literature survey of selected livestock disease outbreaks and historical events.
- Compare distributions of changes in welfare outcomes for selected livestock diseases in the USA that include BSE and HPAI (consistent with recent events in the USA), and RVF (hypothetical shock to the USA meat industry).

Methods

We built a multi-market equilibrium displacement model (EDM) accounting for a vertical supply chain for each commodity/market and substitution between commodities. It is populated with elasticities that account for vertical linkages within species, as well as across species (Pendell et al, 2010). We generated changes in welfare relative to a baseline scenario for beef, pork, poultry & sheep.

Next, we introduced prior information in the form of exogenous shocks based on non-informative and moderately-informative prior densities. Posterior outcomes of welfare impacts from changes in consumer surplus (CS), producer surplus (PS), and total surplus (TS) are then generated along the supply chain for each livestock species. The supports and moments of the prior densities use historical BSE, RVF and AVI outbreak information gathered through an extensive literature review, allowing us to identify scenarios under non-informative priors, as well as small, medium, & large outbreak scenarios under moderately-informed priors.

We explore different scenarios (hypothetical and historical), including shocks at retail demand (adverse consumer reactions), wholesale export supply (trade bans), and farm supply (herd removal or culling). In the future, the model can be augmented with human health, governmental (indemnities or response) or diagnostic testing costs.

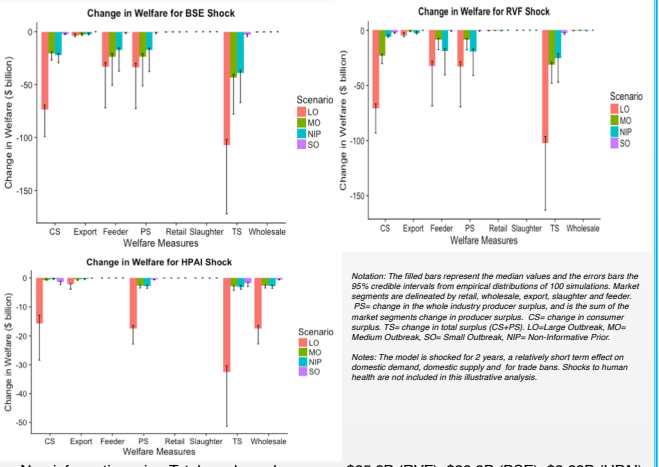
Priors

Shocks	BSE				RVF			
	Non Informative prior	Moderately informative prior			Non Informative prior	Moderately informative prior		
Market segment		Small outbreak	Medium outbreak	Large outbreak		Small outbreak	Medium outbreak	Large outbreak
Retail demand	U(0,1)	U(0,0.05)	U(0, 0.70)	U(0.70,1)	U(0,1)	U(0,0.05)	U(0,0.43)	U(0.43,1)
Export supply	U(0,1)	U(0,0.05)	U(0,0.97)	U(0.97,1)	U(0,1)	U(0,0.05)	U(0,0.852)	U(0.852,1)
Farm supply	U(0,1)	U(0,0.05)	U(0, 0.72)	U(0.72,1)	U(0,1)	U(0,0.05)	U(0,0.848)	U(0.848,1)

Shocks	HPAI			
	Non Informative prior	Moderately informative prior		
Market segment		Small outbreak	Medium outbreak	Large outbreak
Retail demand	U(0,1)	U(0,0.05)	U(0,0.04)	U(0.04,1)
Export supply	U(0,1)	U(0,0.05)	U(0, 0.24)	U(0.24,1)
Farm supply	U(0,1)	U(0,0.05)	U(0,0.26)	U(0.26,1)

Notes: Shocks are all negative % changes in the equilibrium displacement model. BSE shock is only on beef sector, RVF shock is both on beef and lamb sector and HPAI shock is only on poultry sector.

Illustrative Results



Notation: The filled bars represent the median values and the errors bars the 95% credible intervals from empirical distributions of 100 simulations. Market segments are delineated by retail, wholesale, export, slaughter and feeder. PS= change in the whole industry producer surplus, and is the sum of the market segments change in producer surplus. CS= change in consumer surplus. TS= change in total surplus (CS+PS). LO=Large Outbreak, MO= Medium Outbreak, SO= Small Outbreak, NIP= Non-Informative Prior.

Notes: The model is shocked for 2 years, a relatively short term effect on domestic demand, domestic supply and for trade bans. Shocks to human health are not included in this illustrative analysis.

- Non-informative prior: Total surpluses losses are $25.2B (RVF), $38.9B (BSE), $3.23B (HPAI). Consumer surpluses losses are $5.68B (RVF), $22B (BSE), $0.32B (HPAI).
- Moderately-informative prior, small outbreak: Total surpluses losses are $2.64B (RVF), $3.03B (BSE), $1.8B (HPAI). Consumer surpluses losses are $2.23B (RVF), $2.2B (BSE), $1.33B (HPAI).
- Moderately-informative prior, moderate outbreak: Total surpluses losses are $31B (RVF), $43.3B (BSE), $2.82B (HPAI). Consumer surpluses losses are $22.9B (RVF), $20.2B (BSE), $0.68B (HPAI).
- Moderately-informative prior, large outbreak: Total surpluses losses are $102B (RVF), $107B (BSE), $32.41B (HPAI). Consumer surpluses losses are $70.6B (RVF), $73.8B (BSE), $15.7B (HPAI).

Conclusions

- We examine the distributions of outcomes and welfare changes for livestock disease events in the USA. Selected illustrative disease events include BSE, Rift Valley Fever, and avian influenza.
- Non-informative and moderately-informative prior distributions are used to quantify disease shocks, driving the sensitivity analysis. The shocks are based on historical information from past disease outbreaks. Consequently, we justify the shocks as being necessary for an informative exercise rather than a prediction of what could occur in reality.
- Based on illustrative scenarios, the median welfare changes under non-informative priors are most similar to those of the average outbreak under moderately-informed priors.
- Firms along the supply chain and consumers are both burdened by losses, across the disease shocks. Adjustments to our illustrative disease shocks (i.e., priors) would alter these results.
- Generally speaking this approach can provide a clearer picture of the economic outcomes and changes in welfare from livestock disease shocks that could better guide policy and direct more targeted compensation for livestock diseases.

Selected Literature

Harrington, D.H and Dubman. 2008. Equilibrium Displacement Mathematical Programming Models Methodology and a Model of the US Agricultural Sector. Tech Bull n° 1918. Economic Research Service, US Department of Agriculture: Washington, DC

Gelman, A. 2002. Prior distribution. Volume 3, pp 1634–1637. In Encyclopedia of Environmetrics. Edited by Abdel H. El-Shaarawi and Walter W. Piegorsch. John Wiley & Sons, Ltd, Chichester, 2002

Pendell DL, Marsh TL, Coble KH, Lusk JL, Szmania SC (2015) Economic Assessment of FMD Releases from the National Bio and Agro Defense Facility. PLoS ONE10(6): e0129134. https://doi.org/10.1371/journal.pone.0129134

Pendell et al. 2010. Animal identification and tracing in the united states. Amer. J. Agr. Econ. 92(4): 927–940; doi: 10.1093/ajae/aaq037

Further information

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