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Macroeconomic costs to large scale disruptions of food production: The case of foot- and-mouth disease in the United States

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ABSTRACT

We forecast the economic consequences of a widespread contamination of the food system based on a hypothetical outbreak of foot-and-mouth disease (FMD). Since the immediate effect on the livestock sector could affect the entire supply chain and US livestock, meat and dairy exports, we measure these impacts using GTAP, a multi-region, multi-sector computable general equilibrium (CGE) model of the global economy. The immediate "shocks" to the US livestock, raw milk and other animal products sectors indirectly affect all sectors of the economy, as well as international markets and trade. We decompose these effects due to each component of the initial shocks, and estimate the importance of these shocks to the national food system for the Mid-Atlantic Region using IMPLAN. Our GTAP results indicate that losses to the USA economy would be about $11.7 billion, and with the ripple effect throughout the rest of the world including beneficiary nations (Argentina, Brazil, Latin America, Australia and New Zealand) and losers (Canada, Mexico, European Union) would be 14.1 billion. We estimate the proportion of the domestic impact affecting the Mid-Atlantic Region. Based on a regional input–output model of that region, we estimate that total losses in value added are nearly $800 million; losses in labor income total about $565 million; and there are job losses of just over 12 thousand.

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1. Introduction

Over the past decade there has been increased concern about a major biosecurity event affecting US agriculture, its marketing channels, and international trade. This awareness was a natural consequence of the events of September 2001 and for the first part of the past decade there was much focus on what has been termed agroterrorism. The Congressional Research Service (CRS) views agroterrorism as "a subset of bioterrorism, and is defined as the deliberate introduction of an animal or plant disease against livestock or into the food supply with the goal of generating fear, causing economic losses, and/or undermining stability" (Dykes, 2010, p. 11). Currently, our more general concern about biosecurity draws only a fine line between events that might occur naturally and those initiated intentionally by foreign or domestic actors.

Somewhat surprisingly, few economists have taken notice. The related published literature on the matter is scant, despite the billions of dollars spent on prevention and monitoring, and the passage of the Bioterrorism Act of 2002 that altered the way in which agricultural and food products are transported, imported, exported, and otherwise accounted for throughout the food system.[1] What is clear is that in the aggregate the economic consequences of biosecurity events can differ widely. At one extreme, the low-grade avian influenza that affected many flocks in the early to mid-2000's was resolved rapidly by the prevention activities of state departments of agriculture and APHIS. The discovery of a 'mad cow' in December, 2003, was rapidly traced to a Canadian herd; preventative measures ensured that no meat entered the food market. Within weeks all major impacts were resolved, although trade effects lingered for some time. The initial fall in live cattle futures prices due to the dire predictions was negated by a positive outlook.

In contrast, the economic consequences of other biosecurity events may be much more extensive within the United States, but may also

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[1] Of the papers published under the heading of agroterrosim or biosecurity, Elbakidze and McCarl (2006) develop an economic model to establish the optimality conditions for undertaking pre- and post-event actions against the potential introduction of an infectious animal disease. Huff et al. (2004) use the welfare costs of economic losses to an FMD outbreak estimated from a Computable General Equilibrium (CGE) model to approximate the costs and benefits of mitigating action. Elbakidze (2008) investigates mitigation strategies from backyard coop poultry diseases, while Schoenbaum and Disney (2003) from APHIS at the USDA illustrate preparedness and mitigation strategies One cannot escape the potential psychological and sociological impacts on farmers and consumers from a biosecurity event. The impacts of the 2001/2 outbreak in the UK on the rural economy as well as on rural life have been well documented (Scott et al., 2004). Discussions of the economic consequences and the mitigation efforts of historical agroterrorist actions are found in Dykes (2010), Turvey et al. (2008, 2009), Cupp et al. (2004), Wheelis et al. (2002), Breeze (2004), Hennessy (2008) and Foxell (2001).

extend beyond the domestic borders, disrupting trade among countries and may lead to trade embargos as other countries attempt to protect their agricultural industries and food supplies. One could imagine how such a series of economic consequences could accompany the discovery of a case of foot-and-mouth disease in any of the contiguous states. The immediate consequence would likely be a large-scale eradication of livestock herds, but a global embargo, spearheaded by the disease-free regions, may ensue as well. To illustrate, Great Britain's outbreak of foot-and-mouth disease (FMD) in 2001 prompted the slaughter of more than four million farm animals, and led to billions of dollars in losses to farmers. Domestic consumption of beef in the UK fell dramatically, and the decline in British beef exports was a major disruption in international trade.[2] The economic costs were estimated at about 3.1 billion to agriculture and the food chain, and there were further losses of between 2.7 and 3.2 billion to businesses directly affected by reduced expenditures from tourists. This disease is a major constraint to the international livestock trade. In March 1997 with a single pig imported to Taiwan from Hong Kong the disease spread throughout Taiwan in 6 weeks with authorities slaughtering more than eight million pigs and barring exports. Ultimate costs were estimated to be at least $19 billion, $4 billion to eradicate the disease and another $15 billion in trade losses (Dykes, 2010). In 2002, the mere rumor of FMD in Kansas resulted in a $50 million scare (Dykes, 2010).[3]

2. Objectives of the study

Because of this vulnerability of the United States' (or any country's) food system to natural or terrorist-induced contamination, it is important to be able to predict the likelihood and scope of such an event, but also to anticipate the economic implications of an actual occurrence. Given the scarcity of funds for prevention (e.g. increased supply chain and on-farm security), an understanding of the extent of the economic costs is important information for policy makers faced with the difficult decision of where to allocate scarce security resources. It is also important to understand the relationships between such events and consumer demand for agricultural and food products and to document the event's economic effects by major economic sector, as well as its regional, national and international significance.

To contribute to this policy research agenda, we forecast the economic consequences of a hypothetical, but realistic outbreak of foot-and-mouth disease (FMD). The United States has been FMD free since 1929 when the last case was reported in Kansas (see Dykes, 2010). The United States has not experienced a major FMD outbreak since 1929 because it stopped feeding animal parts to animals, and the spread of the disease from terrorists or travelers is highly controlled on a global basis with endemic countries being monitored regularly.[4] Thus, although the likelihood of a natural occurrence is low, the economic consequences can be significant. The immediate effect of this disease on the productivity of the livestock sector could also have a potentially disastrous effect on the entire supply chain and US exports of livestock, meat, and dairy products depending upon the extent of the outbreak and the global response to it. We do not distinguish whether the introduction of FMD was purposeful or natural.[5]

To measure potential impacts from FMD we examine the global context using GTAP, a multi-region, multi-sector computable general equilibrium model of the global economy.[6] We model the immediate impacts of FMD as exogenous "shocks" to the outputs of the US livestock, raw milk and other animal products sectors (which include swine and poultry). Within the CGE model, these shocks, in turn, lead to indirect impacts on all sectors throughout the US economy. In calibrating our initial shocks, we account explicitly for the fact that some primary factors of agricultural production, such as land and capital, are only partially mobile between sectors, particularly in the short run.

Our analysis is unique in several respects. As with other analyses of this kind, we do document the extent of the changes in social welfare due to these exogenous shocks, but we extend our analysis well beyond a discussion of changes in these aggregate measures of well-being. We document changes in domestic output and output prices that underpin these changes in welfare. Because a CGE model captures the indirect effects in international markets, we discuss the specific implications for changes in trade between the United States and other major economic regions in the world. These trade effects could be exacerbated were an outbreak to be accompanied by complete ban on exports of livestock, meat and dairy and other animal products from the United States to FMD-free regions.

Since the extent to which any livestock sector is affected directly is understandably uncertain, we decompose these changes into those attributable to the initial shocks in each of the three sectors affected directly by FMD: US livestock, raw milk and other animal products sectors. We then account separately for the additional impacts due to a complete ban on exports of livestock, animal products, meat, and dairy products from the United States to all FMD-free regions. Our method of decomposing these effects is a new, particular effective way, to examine and understand the nature of complex economic impacts. For example, we could also use our results to scale up or down the size of the initial shocks—thus constructing a range of scenarios that are progressively more serious in their initial shocks without having to resolve the model and without losing our ability to distinguish effects of shocks to individual sectors. From a policy perspective, our alternative strategy may provide some basis on which to set priorities on funding planning, mitigation, and recovery efforts.

Finally, to illustrate the implications of these shocks for regions of the United States, we make a first attempt to estimate the importance of these shocks to the national food system for the Mid-Atlantic Region. This is accomplished by first estimating the proportion of the nation-wide changes in final demand that are realized in the Mid-Atlantic Region. These changes are then incorporated into an input–output model of the Mid-Atlantic Region in order to estimate the size of the indirect and induced effects that ripple throughout this regional economy.

As important as understanding biosecurity threats is to policy makers, economic modeling of biosecurity events is not a simple task especially when investigators want to focus on regional impacts. Regional economic impacts facing the Mid-Atlantic States—a focus of our study—cannot be viewed in isolation from the global consequences from a FMD event. Consequently, we adopt this two-step procedure, with a global economic model providing input into a regional economic model. An advantage of this approach is that the output from the global model provides economic losses nationally and globally which are important to policy makers at the national level (e.g. APHIS at USDA or Homeland Security). National policy makers can compare benefits of

[2] http://www.defra.gov.uk/esg/excel/wplivest.xls.

[3] Dykes indicates that the loss from the March 12, 2002 rumor was on contracts traded at the Chicago Mercantile Exchange. The Kansas Animal Health Commissioner at the time admitted that they were unprepared for such a rumor and that a statement should have been issued immediately to allay such fears http://www.fass.org/fasstrack/news_item.asp?news_id=245.

[4] We thank an anonymous reviewer for indicating this fact. See also Dykes, 2010.

[5] Turvey et al. (2009) show a hypothetical terrorist attack on food or that the finding of BSE can significantly affect consumer risk perceptions, but we have no evidence on what such effects would be from FMD because FMD has no direct impact on human health. As was reported in the UK, we would expect a demand effect because of how food safety risks are perceived generally.

[6] This model, described in detail by Brockmeier (2001), Harrison and Pearson (1996), Hertel (1997), and Huff and Hertel (2001), is widely used for agricultural trade and policy analysis. Others have applied CGE models to the analysis of the economic consequences of natural disasters such as earthquakes and floods (e.g. Rose and Guha, 2004), and more recently to the effects of a hypothetical H1NI epidemic (Dixon et al., 2010). Dixon et al. (2010) point to McKibbin and Sidorenko (2006) for a survey of some CGE literature and simulation results from a global CGE model of the effects of pandemics of various degrees of severity.

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