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Assessing the economic costs of a foot and mouth disease outbreak on Brittany: A dynamic computable general equilibrium analysis

Alexandre Gohin *, Arnaud Rault

INRA, UMR1302 SMART, F-35000 Rennes, France
Agrocampus Ouest, UMR1302 SMART, F-35000 Rennes, France

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ABSTRACT

Outbreaks of animal diseases such as foot and mouth disease (FMD) are of great concern for agriculture. In this paper, we quantify the potential dynamic impacts of such a disease on Brittany, a French region with an important livestock sector. In order to do this, we develop a dynamic computable general equilibrium model that allows us to measure the impacts on the livestock sectors and downstream food industries. We study the impacts of a FMD outbreak including the culling infected animals, a temporary decline in demand, and restrictions on movements of live animals and meats during the FMD outbreak period.

Our results show that economic losses following this disease are spread over many periods even with a one-time shock. We also find that the impacts on the various primary sectors and downstream food sectors are quite different, depending on their initial trade position. Our general equilibrium results show the great incidence of potential constraints affecting factor markets. Capital and wage constraints severely increase the aggregate costs of such disease. These results challenge the definition of a simple efficient management policy for this disease.

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Introduction

Epidemic outbreaks are uncertain events of great concern for agriculture and related sectors. Animal diseases, such as foot and mouth disease (FMD), can lead to severe reductions in animal productivity and may even cause animal death. Moreover, FMD is a highly contagious disease and thus can quickly cause large production and economic damages in livestock-intensive regions. Because infected animals are usually killed and movements of healthy animals in infected areas are prohibited during an FMD outbreak, upstream and downstream industries are also negatively impacted by a reduction in their activity. Livestock farms and industries located outside the infected area may not necessarily benefit from a FMD outbreak. It depends on the price evolution of livestock products which may ultimately decrease if import bans by foreign countries and/or a reduction in domestic consumption are larger than the supply reduction in the infected area. Thus a FMD outbreak can have important economic costs for infected farmers and the whole food chain as well. These costs extend to the whole economy if other sectors are also directly affected by the outbreak. For example, some studies show that the 2001 FMD outbreak in the United Kingdom (UK) imposed important economic losses on the whole British economy due to the impact on tourism (Blake et al., 2002; O'Toole et al., 2002).

The computation of the expected indemnities of well known risks does not pose great challenges. This allows for the pricing of private risk instruments, such as insurance, and hence the optimal sharing of these expected costs among economic agents. A FMD outbreak is not presently an insurable risk because expected indemnities are difficult to compute for at least the three following reasons. First, a FMD outbreak is today characterised by an uncertain, presumably low, probability of occurrence with potential considerable and systematic economic losses. From an economic point of view, this first characteristic already makes FMD potentially a catastrophic and non-insurable risk. Second, the economic costs of a FMD outbreak depend on the public measures taken to manage and/or eradicate the disease. Public authorities may implement preventive actions to limit the occurrence and extent of FMD effects, through regular veterinary monitoring. In addition, during the crisis period they can choose among alternative strategies, including the culling of infected herds, the preventive stamping out of animals located around the infected zone, and the vaccination of animals located within a ring vaccination zone. These discretionary public decisions in control strategy have different consequences with respect to the length of measures, the number of killed animals and, hence, the length and magnitude of

* Corresponding author. Address: INRA, UMR SMART, 4 allée Adolphe Bobierre, CS 61103, 35011 Rennes Cedex, France. Tel.: +33 (0)2 23 48 54 06; fax: +33 (0)2 23 48 53 80.

E-mail addresses: alexandre.gohin@rennes.inra.fr (A. Gohin), arnaud.rault@rennes.inra.fr (A. Rault).

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economic costs. Third, the dynamic dimensions linked to animal production economics add another challenge to the computation of expected economic costs. Effects of a FMD outbreak do not stop with the eradication of the disease since time is obviously needed to rebuild the livestock herd after preventive and curative culling.

With FMD, we are thus presently in a second best world characterised by incomplete contingent markets in the Arrow Debreu sense and potential optimal public intervention. In the European Union (EU), public measures funded by a veterinary fund include, in particular, co-financing of emergency measures for the slaughter of infected animals and the support of a vaccination bank. Exceptional market support measures can also provide support to farmers and breeders affected by restrictions imposed by the veterinary authorities. However, this EU public policy is currently under debate in the context of the Common Agricultural Policy (CAP) reform, due to the heterogeneous national complementary measures leading to potential distortions on the EU market, and also due to a lack of clear and transparent rules for exceptional market measures.

In this context, the purpose of this article is to provide an assessment of the market and welfare impacts of a potential FMD outbreak in a European livestock-intensive region. Our ultimate goal is to compute the aggregate and dynamic economic costs of such a disease and their distribution both among economic stakeholders and through time. Such an assessment is the necessary first step in providing new insights and in helping to design an optimal articulation of private/public permanent/crisis measures to cope with such stochastic event.

From a methodological perspective, the cost-benefit analyses of FMD have long used static economic models focusing on the direct costs incurred by infected farms (see for example the review by Rich et al., 2005). These first analyses have been improved by introducing the indirect effects on other economic agents. This has been done using static input–output models (without price effects) or using Partial Equilibrium (PE) and Computable General Equilibrium (CGE) models (with price and income effects). The dynamic dimension has also been introduced into the first static cost-benefit analyses. In particular, epidemiological models have been coupled to economic ones focusing on production, in order to analyse the costs of the disease over time in relation to the evolution of the animal health context. Recent works have started to include dynamic economic elements in PE models. In particular, Zhao et al. (2006) build a PE model where farmers take optimal decisions based on intertemporal profit maximisation behaviours. These authors show that the impacts of FMD change from year to year before returning to a new steady state, which is typical when studying animal supply responses. In the same vein, Rich and Winter-Nelson (2007) and Paarlberg et al. (2008) use PE models to show the short term and long term effects of an FMD outbreak, which are highly dependent on the length of livestock production cycles.

While these dynamic PE analyses provide valuable insights, they measure neither the economic impacts on non-agricultural and food sectors nor the macro-economic impacts of such a disease. Yet determining these effects can be useful in order to define appropriate risk management schemes. This can be done using a dynamic CGE model as pioneered by Philippidis and Hubbard (2005). They use the dynamic version of the Global Trade Analysis Project (GTAP) model to show the lasting effects of such a disease. However, their analysis uses the GTAP data where the different livestock animals are not distinguished. Hence, the dynamic biological constraints are imperfectly captured in their analysis. Moreover, these authors assume that all primary factor markets are perfect. This implies that labour and land are fully mobile between sectors and that the capital market is efficient: investment by sector is never constrained nor faces sunk transaction costs. Accordingly these authors implicitly assume that the costs of FMD incurred by the livestock and related sectors are shared with all other economic sectors (through the impacts on labour and land) and are efficiently spread over time (through the impacts on sector investment). In other words, these assumptions of perfect factor markets minimise the aggregate economic costs of a FMD outbreak (as already mentioned in another risky context by Leathers and Chavas, 1986). Yet factor markets in the EU are characterised by different distortions/imperfections, such as minimum wages that imply involuntary unemployment, or credit rationing implying constrained sector investment (see, for instance, Blancard et al., 2006).

Our methodological contribution is to build a new dynamic CGE model in the vein of Philippidis and Hubbard (2005) improved in two ways. The first improvement consists of the explicit specification of all livestock sectors and their herds, so that the multi-annual dynamic biological constraints for cattle and swine are captured in our analysis. The second is the specification of rigidity/imperfections in labour and capital markets. This allows us to measure the sensitivity of economic costs of a FMD outbreak to these real characteristics of factor markets. Our dynamic CGE model is applied to Brittany which is the most livestock-intensive French region. Brittany ranks first in terms of French milk, veal, pig and poultry production, and second in terms of cattle production. Farm and food processing industries represent 12% of Brittany's total employment, compared to 6% at the national level (Cébron, 2004).

The article is organised as follows. In the second section we present the main specifications of our dynamic CGE analysis. We first describe the general features of our model and then detail our novel representation of the cattle and swine sectors. We also explain how we specify distortions and imperfections in the primary factor markets. In the third section, we report our simulation experiments. First, we assess the economic costs of a potential FMD outbreak assuming perfect factor markets. Then, we measure the robustness of these costs to distortions and imperfections in the primary factor markets. The last section concludes with some policy and research recommendations.

Modelling framework

In this section we present the main specifications of our dynamic CGE model. First we provide a general description of the standard version of our model, highlighting the dynamic behaviours of the producers and the macro-economic closure of the model. Then we describe the livestock sectors with the dynamics implemented to reflect the animal cycles. Finally we detail the modelling of imperfections/distortions on factor markets.

Our model goes into great detail on the livestock sectors and downstream-related sectors. To do this, we built a Social Accounting Matrix (SAM) for the Brittany region calibrated for the year 2003 owing to data constraints. In particular, the data set on agricultural production costs could be completed thanks to the database of the Common Agricultural Policy Regional Impact (CAPRI) model. This SAM gives information on 50 sectors in total, including 23 agricultural activities and 53 products. Of these products, 25 are agricultural ones (see Annex Table A1). It should be underlined that we allow for multi-product activities, such as the dairy cow activity producing milk, bovine for slaughter, new born calves and organic manure.

Main features of the model

The basic structure of our dynamic CGE model is standard for a single country model in an open economy (see, for instance,

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