The economic and poverty impacts of animal diseases in developing countries: New roles, new demands for economics and epidemiology

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ABSTRACT

Animal disease outbreaks pose significant threats to livestock sectors throughout the world, both from the standpoint of the economic impacts of the disease itself and the measures taken to mitigate the risk of disease introduction. These impacts are multidimensional and not always well understood, complicating effective policy response. In the developing world, livestock diseases have broader, more nuanced effects on markets, poverty, and livelihoods, given the diversity of uses of livestock and complexity of livestock value chains. In both settings, disease control strategies, particularly those informed by ex ante modeling platforms, often fail to recognize the constraints inherent among farmers, veterinary services, and other value chain actors. In short, context matters. Correspondingly, an important gap in the animal health economics literature is the explicit incorporation of behavior and incentives in impact analyses that highlight the interactions of disease with its socio-economic and institutional setting. In this paper, we examine new approaches and frameworks for the analysis of economic and poverty impacts of animal diseases. We propose greater utilization of “bottom-up” analyses, highlighting the strengths and weaknesses of value chain and information economics approaches in impact analyses and stressing the importance of improved integration between the epidemiology of disease and its relationships with economic behavior.

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1. Introduction

Animal diseases pose significant threats to livestock sectors throughout the world, both from the standpoint of the economic impacts of the diseases themselves and the measures taken to mitigate the risk of disease introduction or spread (Perry and Randolph, 2003). These impacts are multidimensional and not always well understood, complicating effective policy response. This is particularly the case in much of the developing world, where livestock play an important part in household livelihoods and in some circumstances serve as a pathway out of poverty (Perry and Grace, 2009). In such contexts, where livestock contribute food, income, draught power, an asset base, and various social functions, the impacts of animal disease, and in particular their ramifications on poverty, may be difficult to tease out (Perry and Rich, 2007; Randolph et al., 2007; Perry and Grace, 2009).

The need for animal health impact assessments has been rising in recent years, given the increased prominence of animal health issues on the global stage. On the one hand, increased globalization and rising demand for meat products, particularly from the developing world, provide new opportunities for global suppliers and increase access to high-quality sources of protein to a wider range of consumers, including the poor (Delgado et al., 1999). A constraint to this potential for market access is the abil-
ity of suppliers to meet ever-increasing requirements for food safety and sanitary and phytosanitary standards (SPS), though the potential rewards are often large for developing countries to reduce the prevalence of animal diseases. On the other hand, globalization also represents a threat, particularly to the developed world, in increasing the risk of pathogen introduction (especially those with human health impacts), particularly from developing regions with neither the incentive nor the capacity to control disease but which can serve as disease reservoirs (Winter-Nelson and Rich, 2008). As both the risks and rewards from the livestock trade have increased over the past several years, policymakers require greater amounts of information to understand the implications of animal diseases on a host of issues, including markets, trade, poverty, and human health.

On the supply side, significant efforts have been made in recent years in elucidating the role that economics and epidemiology could play in understanding animal disease impacts and improving public policies related to animal disease control. Some of these have been presented at past International Symposia on Veterinary Epidemiology and Economics (ISVEE). At ISVEE IX in 2000, Perry et al. (2001) summarized the ways in which partnerships between economics and epidemiology play an important integrative role: (i) priority setting: identifying which diseases come first, taking into account their institutional and economic context; (ii) decision-making: understanding what options are available for decision makers and presenting (hopefully) an unfiltered perspective of the costs, benefits, and tradeoffs inherent in them; and (iii) disease control implementation: providing guidance into the delivery of effective animal health interventions. A number of reviews have been published in recent years that have thoroughly evaluated the various economic impacts of animal diseases (for example Dijkhuizen et al., 1995; McLeod and Leslie, 2001; Rushton, 2002; Otte et al., 2004) and the economic tools that could be employed to provide better information for policymakers (Rushton et al., 1999; Rich et al., 2005a,b; Rushton, 2009). Similarly, past and current ISVEE’s have provided us with numerous quantitative models of varying levels of sophistication that illustrate the epidemiological and/or economic impacts of countless diseases and alternative scenarios and strategies that could be employed for their control.

From the standpoint of our understanding of poverty impacts, the past decade has further witnessed a number of research studies that have broadened our knowledge of important poverty dimensions of animal disease. In the context of foot-and-mouth disease (FMD), work by Brian Perry and others in Southeast Asia (Perry et al., 1999, 2002; Randolph et al., 2002) focused on the livelihoods effects of FMD. Similarly, subsequent work in Zimbabwe (Perry et al., 2003) pioneered the integration of sophisticated economic and epidemiological modeling to assess the distributional impacts of alternative FMD control strategies, both on different income groups and on different actors in the value chain. Perry and Rich (2007) recently provided a conceptual framework for understanding the various poverty reduction facets of FMD control based on a number of contextual attributes of different production systems. The Food and Agriculture Organization of the United Nations (FAO) has commissioned a number of studies on the economic impact of avian influenza in Asia (see Rushton et al., 2009a,b), while at present, the International Food Policy Research Institute (IFPRI), the International Livestock Research Institute (ILRI), FAO, Royal Veterinary College, and the University of California, Berkeley have partnered to research the socioeconomic impacts of avian influenza in Asia and Africa, some results of which were presented at this year’s ISVEE (for example, Ifft et al., 2009; Rich et al., 2009c).

Despite the wealth of information and new data, despite the greater sophistication in our analytical toolkit, despite increased awareness of alternative policy options, and despite greater knowledge of the poverty dimensions of animal diseases, our ability to translate these accomplishments into action to influence animal health policies that address the reduction of poverty has been relatively limited. Why is this? One causal argument is that an overwhelming majority of our research in this integrated discipline has been made at a “macro” level and with a developed country mindset, which often focuses on disease eradication at any cost. As researchers and policymakers in the developing world are often influenced and/or trained from such first world perspectives, it is of little surprise that responses to animal diseases in the developing world are often modeled on those in more developed settings. As such, the overriding concern is often the elimination of disease, with issues of disease mitigation, equity, gender, poverty, and so on taking secondary importance. Issues of environmental conservation and climate change feature prominently, where social consciousness, influenced by good communications (and much less direct concern regarding poverty per se) plays an increasingly important role. However, the impact of livestock diseases in developing country settings often have broader, more nuanced effects on markets, poverty, and livelihoods than they have in developed settings, given that livestock often serve more diverse commercial (e.g., as a source of income) and non-commercial (e.g., cultural) roles. Thus, control strategies based on culling or mass vaccination may fail to recognize the constraints inherent among farmers, veterinary services and other value chain actors.

A more careful analysis suggests a more glaring lacuna, one expressed as a critical need by Perry et al. (2001). In their paper (p. 257), they noted that “much remains to be done to improve the ‘institutionalization’ of veterinary epidemiology and economics”; this institutionalization of tools and processes, particularly in developing country settings, remains inappropriately weak. But behind this gap is a more subtle issue. In particular, our focus as economists and epidemiologists has overwhelmingly been what economists term as normative2: trying to provide guidance on how agents should behave. Where we have directed far less attention is on what economists call positive principles, that is, understanding and predicting why

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2 According to Wikipedia, normative has specialized meanings in several academic disciplines. Generically, it means relating to an ideal standard or model. In practice, it has strong connotations of relating to a typical standard or model.
agents behave as they do. Positive principles place particular attention on the role of incentives in determining behavior and actions made by various decision makers.

Why does this matter? Consider a typical developing country setting for livestock production, one in which there are high transactions costs, considerable risks, and wide variations in incomes and commercialization of livestock production (e.g., smallholder vs. commercial). Such settings often contain long supply chains, with a multitude of producers, traders, processors, and retailers whose livelihoods depend on the livestock sector. In addition, there is often a gender dimension to livestock production, such as in many smallholder poultry systems where women take responsibility for the maintenance of household flocks (Riise et al., 2005). In the event of an animal disease outbreak (or in circumstances of endemic disease), the response of different stakeholders to the disease will be contextualized in their unique circumstance and constraints, with their incentives for compliance based on such context. Yet the interaction of such a heterogeneity of actors with and among each another matters significantly from the standpoint of disease spread and its control, as do the socio-economic and institutional characteristics of such heterogeneity (Rich et al., 2005a). Models or analyses that tell us what decision makers should do, while ignoring the context in which different actors (including decision makers themselves) might actually do, greatly limit our analytical power to contribute towards effective policymaking, particularly policies that are “pro-poor” in nature. Furthermore, developing countries are often characterized by policymaking environments in which there is limited enforcement of rules and regulations, where trust and credibility in government is low, and levels of social responsibility necessary to adequately address animal health emergencies and comply with their response are restricted to a minority elite. These differences are of critical importance in the developing world given the divergence of incentives among different stakeholders and reflect an important need for a shift in thinking from top-down normative approaches towards bottom-up positive approaches. While recent research has slowly begun to make this shift in understanding the influences of practices on the effectiveness of policies (Rushton et al., 2006, 2007; De Rooji et al., 2007), more research and emphasis is required in this direction. Moreover, while we concur with Rushton et al. (2007), who emphasize the need to integrate political economy and institutions in animal health research, we also see a need to focus more broadly and systematically on incentives and the behavior of those institutions and political actors as the central theme to understand economic impacts. New tools, frameworks, data collection tools, and data management systems will thus be needed to provide improved empirical support for decision makers and public policy. In many respects, this will require a closer integration with the epidemiological side of disease impacts, overlaying the people, institutions, and context on top of the biological drivers of disease.

This paper has four broad aims. First, it reviews the multitude of livelihood and poverty impacts of animal diseases in developing countries. The analysis provides examples from three important diseases facing the developing world – Rift Valley fever (RVF), Highly Pathogenic Avian Influenza (HPAI) and FMD – though many of the lessons drawn can be applied to a multitude of other contexts. Second, it analyzes these effects through a poverty and value chains lens, putting into context the constraints faced by actors in the livestock sector and how these complicate the ability of, and incentives for, effective response. Third, the paper highlights ways that incentives can be better aligned for disease control through a discussion of supply-side and demand-side factors that could promote improved compliance. The paper concludes with a discussion of research needs for economic and epidemiological analysis in such environments, providing examples of innovative approaches and data collection protocols currently employed in ongoing studies. Lessons for developed country settings are highlighted as well, and for future synergies between economics and epidemiology.

2. Overview of the economic and poverty impacts of animal diseases

Animal diseases engender a multitude of impacts on an economy, many of which are disease-specific. For instance, zoonotic diseases like RVF or HPAI, both of which have diverse disease-specific effects of their own, have much more visible and severe impacts on animals and humans alike (for instance, in terms of mortality) than a disease such as FMD and can cause negative, as well as pronounced short-term, effects on domestic and international markets. At the same time, because of its potential for rapid international spread and effects on animal productivity, international markets for beef are segmented on the basis of FMD status, with higher price premiums available for supplying countries that are both FMD-free and which do not vaccinate their herds (Jarvis and Rich, 2007). Consequently, both epidemic and endemic FMD cause a host of diverse impacts, extending from the farm-level to the national economy that can be significant. For example, widely published estimates of the UK FMD outbreak in 2001 highlight economic losses of over US$ 12 million, over half of which was absorbed in non-agricultural sectors such as services and tourism (McLeod and Rushton, 2007). Moreover, the presence of endemic FMD in most of sub-Saharan Africa closes most high-value export markets for beef such as the European Union, United States, Japan, and Korea. On the other hand, not all animal diseases have such negative, broad-based economic consequences. McLeod and Rushton (2007) note that diseases like brucellosis, which do impact both animals and humans from a health perspective, often have relatively limited market impacts compared to diseases such as FMD, which only affect animals.

Fig. 1 illustrates a conceptual framework for analyzing the impacts of FMD, although many of the principles are applicable for most animal diseases. This framework distinguishes both between impacts based on disease status (i.e., whether the disease is present vs. mitigations to prevent its entry) and between levels of economic impact (i.e., farm-level vs. national and sectoral impacts). Where FMD is not present, its impacts are concentrated in risk management efforts at a national level and at the farm-level to prevent future incursions. Risk mitigations often have
significant economic costs, both in terms of direct outlays in *inter alia* surveillance, veterinary services, fencing, production practices and traceability programs, and in terms of the opportunity costs of stakeholders in the livestock value chain. Once a disease has entered a production system, it causes a host of impacts at the farm-level (directly related to livestock production and indirectly associated with other farm and non-farm activities), on rural livelihoods, government expenditures on containment (e.g., vaccination, culling, compensation), and in related and unrelated sectors of the economy (e.g., livestock processing, tourism, transport).

Table 1 extends this conceptual framework to tease out the contextual aspects of animal diseases that determine whether any specific disease has more or less impact on a given dimension. These dimensions are classified into five categories: disease characteristics, production characteristics, market characteristics, livelihood characteristics, and control characteristics. This framework synthesizes many of the impacts previously identified by McLeod and Leslie (2001) and conceives an alternative, though complementary, platform for scoring the impacts of disease. While the McLeod and Leslie (2001) framework looks at potential direct, indirect, social, and political benefits to score hypothetical control programs, our framework looks more generally at the contextual drivers that may influence the relative severity of an outbreak or endemic disease setting itself. First, disease characteristics refer to biological or epidemiological aspects of the disease itself that modulate its general impacts. FMD, for instance, has limited impacts in terms of animal mortality and none on human health. However, its potential for international spread implies economic impacts that can span long distances, while its significant impacts on animal morbidity have ramifications on production and marketing alike. Second, a host of different production characteristics of an afflicted sector will also determine a disease’s relative impact. Certain diseases may be more prone to spread in intensive rather than extensive or backyard systems, with implications on the types of producers affected. The degree to which production systems interact through market or non-market means will also be important in determining spread and thus impact. Similarly, as systems provide a host of by-products and services, such as milk, manure, and draught labor in cattle-derived systems, measurement of a disease outbreak’s impact should be sensitive to such secondary effects. More subtly are issues related to production cycles and seasonality. How long a disease occurs and when it occurs can both influence its economic impact. For instance, Rich and Wanyioke (2010) found that the 2006/2007 RVF out-
break in Kenya had larger impacts on producers because it struck at a period when prices were seasonally higher. Similarly, the production cycle of a particular breed of livestock (e.g., chickens vs. cattle) will influence the ability and length of time necessary to restock animals lost to animal disease. Finally, while an animal disease might affect a particular production system (e.g., smallholder or commercial producers) equally, the economic ramifications of losing particular types of animals may be rather diverse. Otte et al. (2008) note that grandparent stock fetches higher market values than broilers, such that an animal disease outbreak will disproportionately affect breeders more than broiler operations, for example.

Third, the degree of market impacts of an animal disease will largely rest on the characteristics of the markets affected. While more commercialized livestock sectors will more obviously and directly face the brunt of a disease outbreak, the resilience of smallholders and poor pastoral producers may be severely tested if markets are closed due to animal disease. An area of impact which is often overlooked concerns the nature of value chain relations within the livestock sector itself. Indeed, most research and public policy overwhelmingly focus on the production side of animal health emergencies, when much of the impact of the disease is felt among downstream actors (Otte et al., 2008; Rich et al., 2009c). Indeed, traditional value chains may often be relatively complex and imbued with a host of stakeholders that are overlooked in most analyses of animal diseases. In the case of RVF in Kenya, Rich and Wanyioke (2010) found severe impacts among casual workers in slaughterhouses that were laid off for over two months and those which remained employed, but whose income fell significantly because their pay was linked to slaughterhouse throughput. They also observed a majority of traders unable to commence operations post-outbreak, as their cash reserves were depleted in the absence of alternative remunerative activities. The degree to which the agricultural sector influences non-agricultural activities will also play an important role on impact and control strategies. For instance, while HPAI was of prime concern to the Thai poultry industry, given its importance as an export sector, an even greater concern was the tourism sector, which declined in the wake of the HPAI outbreak (McLeod and Rushton, 2007). At the same time, the interests of the commercial poultry industry and agribusiness, which dominate much of the political economy in Thailand, converged to adopt a comprehensive culling-based control strategy to stamp out the disease (Safman, 2009).

Fourth, livestock have important livelihoods impacts, which can be both market and non-market based in nature. For commercial producers, the loss of animals due to a disease outbreak can negatively impact livelihoods when such production represents the predominant source of income. These impacts can have important gender differences, particularly in small stock systems that are often the remit of women. Even where livestock represent part of

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a diversification strategy, livelihoods impacts are no less important. In some instances, livestock will perform an important social or cultural role that could impede successful control efforts. Finally, the logistics behind control strategies further influence and contextualize a disease’s impact. These include technical and resource aspects of the control strategy itself (e.g., the effectiveness of vaccination) and recurrent costs related to control, capacity, and surveillance once an outbreak is either contained or is endemic. Control measures themselves could have externalities that impose further costs on an economy. For example, aca- ricides used to control tick-borne diseases could have negative impacts on the environment and groundwater, which in turn could impact other agricultural sectors. Finally, institutional capacity has an important influence on control itself, in terms of the human and financial resources necessary to institutionalize response to animal diseases.

One of the salient and repeated aspects of the framework above concerns the role of interactions among stakeholders. In traditional analyses of animal health impacts, the focus is generally at the production (farm) level, with interactions limited to intra-farm (or intra-herd) transmission or the broader macro-economic linkages between the farm sector and the rest of the economy. As noted above, however, the production side of the livestock sector is only one part of a larger chain, with interactions within the farm sector, with downstream value chain actors, and the economy as a whole. Each actor in the value chain will be affected differently both by animal diseases as well as mitigations aimed at their control. This heterogeneity and diversity of interacting agents complicates response, given that the nature of interactions is often complex and unknown, while different actors will have different incentives depending on the contribution of livestock to their livelihoods. Most empirical models fail to address these nuances and, more importantly, fail to explicitly recognize the contextual attributes of different stakeholders that might impede response.

In order to remedy this gap in our knowledge, we need to look more holistically at the livestock sector as a system of interacting actors, each with its own values and constraints that shape the incentives each has for control. In the next section, we motivate the use of the value chain methodology to understand this diversity and to help us as researchers provide improved guidance for decision makers.

3. The role of value chains in animal health assessments

The concept of the value chain is not a new one in economics. One of the precursors to modern value chain analysis is the filière (literally a “thread”) approach developed in France in the 1960s and 1970s to map sector-level relationships (Kaplinsky and Morris, 2001). Porter (1980) brought the term to the business literature to highlight the business networks within (and outside) a firm which help to define its competitive advantage. Value chain approaches moved to the development literature in the late 1990s and have become a rather fashionable method to map out agricultural market systems in developing countries (see Rich et al., 2009b for a review and relevant literature). Value chain analysis was formalized and codified by researchers at the Institute for Development Studies (IDS) at the University of Sussex in a seminal “handbook” on value chain research (Kaplinsky and Morris, 2001), though sadly much of the applied research using value chains focuses on the ad hoc mapping of the actor linkages and ignores the rich and cogent structure that IDS researchers developed.

Value chain approaches have not been extensively applied in livestock settings until relatively recently. Humphrey and Napier (2005) provided a generic framework for ways in which value chain analysis could be utilized in livestock systems. However, the last three to four years has seen a relative surge in application in the context of animal health emergencies, much of which arose from work funded or commissioned by the Wellcome Trust, FAO and DFID in the context of HPAI (see Rushton et al., 2009a,b for recent work in SE Asia). Kobayashi (2006) illustrated the utility of value chain analysis in the context of avian influenza control. In her analysis, Kobayashi demonstrated how value chain mappings could not only highlight the interactions, flows, and governance mechanisms inherent in different poultry sector marketing channels in a visual format, but also how they could identify bottlenecks or critical control points in the chain that may mitigate against effective compliance.

As detailed in Kaplinsky and Morris (2001) and summarized in Rushton (2009) and Rich et al. (2009b), value chain analyses focus on four main areas:

- **Mapping the value chain**: describing the actors inherent in all stages of production, distribution, processing and end-sales, including service providers, and the nature of such interactions both qualitatively and quantitatively (e.g., flows and values of products between actors and different chains) (Rushton, 2009). Fig. 2 provides an illustration of a simple value chain mapping, while Fig. 3 details a much more complicated value chain in the layer sector in Indonesia;

- **Understanding governance in the value chain**: assessing power relationships in the chain in terms of who coordinates economic activities, standards, and transactions, and the means by which this is done (e.g., ad hoc arm’s-length transactions, relationships, vertical coordination) (Rushton, 2009; Te Velde et al., 2006);

- **Upgrading in the value chain**: identifying opportunities for improving the position of a particular actor within the chain, through more efficient (or new) processes, development of new products, changing the mix of products and activities within a chain to add value, or moving into new chains altogether;

- **Distributional issues in the value chain**: highlighting equity considerations in the value chain, in terms of who bene-

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2 The term “critical control point” has a specific meaning in the HACCP literature that is not the same as what is sometimes used in the value chain literature. In the latter, a critical control point refers to key bottlenecks in the chain that might impede efficiency, for example. However, it could also refer to specific risk or socio-economic aspects of the chain that could modulate disease spread as well (e.g., Taylor et al., 2008).
fits from participation in the chain and various shares of value distributed among different chain actors. These can look at different typologies of actors based on household income, gender, or production system.

In the context of the poverty impacts of animal diseases, the value chain framework is particularly useful in identifying both the different types of chains that predominately incorporate poor stakeholders as well as segments

of the chain that may have more or less poverty impacts from disease than others. Fig. 4 provides an illustration of major functions within a simple livestock value chain, the main categories of stakeholders involved in the chain (and affected by animal disease), and a subset of actors in which poverty considerations may be extremely important. Such information could be informed by a qualitative value chain mapping as discussed above. On the production side, important players include livestock and crop producers, the latter providing a source of additional employment for livestock (e.g., plowing) and a source of feed for livestock producers. Service providers, including veterinarians, banks and other sources of financing (e.g., moneylenders), feed stores, and market agents in sales yards (brokers, handlers, etc.) are particularly important agents in upstream markets, as are government officials (particularly in agriculture and livestock ministries) given that public policy related to animal health tends to focus on the production side. In developing countries, there will often be significant heterogeneity amongst production-side actors, with smallholder or backyard producers and pastoralists dominating much of the landscape. Much of the poverty impacts of disease could potentially be concentrated among such actors, depending on the importance of livestock on their livelihoods and other dimensions of disease expressed in Table 1. Governments are tasked with public policies to mitigate those impacts, although the capacity of government to effectively provide services to deal with animal diseases (either prior to disease incursion in terms of surveillance and veterinary services or during an outbreak) can be quite limited in developing countries. Indeed, government decision-making and prioritization of different diseases can be wrapped up in a host of political economy and public administration issues that reflect neither technical nor poverty impact considerations. For example, ILRI (2009) found that timely responses to RVF in Kenya were constrained by limited preparedness or contingency plans necessary to coordinate different government ministries. At the same time, service providers, particularly in the informal sector, are no less vulnerable to disease impacts. As market action declines due to epidemic or endemic disease, the volume of work available in petty retail outlets and by service providers in markets would necessarily fall, causing negative multiplier effects in the rural economy.

At the next stage of the value chain, namely distribution, major stakeholders include small-scale traders and assemblers and informal trading systems co-existing with larger, commercial traders and formal transport linkages. Important service providers at this stage of the chain include financial intermediaries (banks, moneylenders, and microfinance) that facilitate the provision of credit between the producer and downstream part of the value chain. Because informal traders are often extremely capital constrained and operate on relatively low margins, a decline or loss in business resulting from animal disease can have pronounced economic impacts, which can be exacerbated by
the limited alternative non-farm activities found in rural areas in the developing world. In addition, the loss of business activities can further restrict the general supply of credit in the rural economy, depressing a host of other non-farm rural sectors.

At the processing side of the value chain, the dominant players include slaughterhouses and processing facilities, which can be of varying scales and degrees of formality. Service providers contribute to this link in the chain, but increasingly important actors at this stage (and further down the chain to retail) are regulatory bodies that govern standards for food safety and quality. The degree to which such regulatory bodies are present varies markedly in the developing world, and there is often a bifurcation in standards between those oriented towards export markets and those aimed at the domestic market. Animal diseases necessarily affect the processing sector through decreasing daily throughput and, depending on the degree of export orientation, increasing the regulatory burden on government and processing sectors alike to comply with international standards. While processing plants and slaughterhouses do not always contribute significantly to formal employment in the developing world, there are often a range of overlooked poverty impacts on wage and casual labor in abattoirs and processing plants, many of whom are often paid on the basis of production volume, not to mention ancillary and informal service providers (e.g., cart pushers, scrap sellers, manure removers, etc.) whose livelihoods depend on the operation of the slaughterhouse (Rich and Wanyiwoke, 2010). As with traders, given the limited amount of alternative activities in non-farm rural areas, the closure of slaughterhouses and processing plants can have sharply negative impacts on the rural economy. Similar impacts can be felt in the retail sector, particularly among local butchers and employees of retail shops and supermarkets.

As illustrated above, the value chain framework provides a useful way to organize and neatly summarize the broad range of impacts that animal diseases can generate. But value chain analysis can provide much more than a template for analysis. Indeed, a particular strength of the approach is in its focus on relationships, characteristics, and dynamics that take place among value chain actors. The focus on governance highlights what types of marketing structures govern transactions in the chain and the extent to which power relationships (e.g., monopoly or monopsony power) or coordination mechanisms underpin such dynamics. An analysis of governance may, for example, determine whether transactions between segments of the chain are governed by ad hoc arms-length transactions or more formalized types of vertical coordination. In the context of animal disease, this may matter for a couple of reasons. First, where transaction mechanisms are more formalized, the ability of diverse chain actors to coordinate activities in a manner that promotes greater biosecurity efforts or control of disease is potentially enhanced, particularly if regulations and standards are pushed and championed by a key player in the chain. In developed countries, supermarkets often coordinate transactions within the chain to ensure quality specifications are met, which often serve as a source of competitive advantage between retailers (Dolan and Humphrey, 2000). In the context of livestock production, a good example of this is the efforts of FAN (Farm Assured Namibian) Meat in Namibia which coordinates public and private efforts at traceability and certification to ensure market access in high-value EU export markets (Perry et al., 2005). Conversely, where market power is concentrated among one segment of the chain, incentives for compliance by other chain actors might be reduced, particularly if such market power distorts appropriate price signals or information received by other actors. Furthermore, where governance mechanisms are loose or informal, or where a mix of value chains interact, each with its own type of governance system, disease control can also be problematic.

Similarly, the concept of upgrading can be adapted in a manner that allows for the analysis of animal disease and poverty impacts. Traditionally, upgrading refers to the process by which new functionalities within the chain can be conceived to add value for different chain actors. However, we could also think of upgrading from the standpoint of how the value chain reacts to variations in market opportunities, external shocks and other phenomena, and the process by which value chain actors adjust to such changes. Viewed in such a manner, value chain analysis becomes an important vehicle for assessing behavior.

Combining the value chain mapping with an analysis of governance and upgrading provides a much richer framework for contextualizing the economic impacts (particularly the poverty effects) of animal disease. In particular, value chain analysis identifies not only who is impacted from animal disease, but (i) how and why they are affected in the way they are, and (ii) an indication of how they might behave and adjust in response to such events. Such information could further be used to highlight the constraints faced by different chain actors, particularly the poor, as a first step to synthesize where possible critical control points might lie within the chain that could undermine control efforts. Such critical control points could be interfaced with the results and methods utilized in risk analysis to provide socio-economic context behind more technical components of animal diseases.

In Table 2, we provide a summary of potential constraints faced by selected value chain actors that could influence their inability to engage in appropriate disease control steps and a set of what we term “supply-side” and “demand-side” incentive mechanisms. Supply-side mechanisms are those that directly improve the capacity of a given actor to comply with a disease control measure, while demand-side mechanisms are those that serve to induce compliance by raising demand for a particular chain actor’s good or service. For instance, producers are often constrained by a number of factors, including limited financial resources that make disease control mitigations (both preventive and recurrent) too costly; limited access to markets which reduces the prices received by producers; and limited access to government services, which could reduce the potential productivity of animals. Improving the incentives faced by producers requires mechanisms that either directly reduce compliance costs (supply-side investments in technology, for instance) or improve market access through changes in regulatory environments.
(e.g., commodity-based trade proposals—see Rich et al., 2009a). Incentive mechanisms need not be reward-based; for instance, demand-side incentive mechanisms could also include fines for producers not complying with legislated biosecurity practices (Gramig et al., 2009). Similar types of constraints and incentive mechanisms can be identified for downstream actors and government agents whose policies influence the nature of the chain itself.

While value chain analysis provides a useful perspective on the economic impacts of animal disease, a major weakness of the approach is that it is largely qualitative and descriptive. Rich et al. (2009b) remark that value chain analysis is generally devoid of sophisticated quantitative methodologies that are necessary to highlight more specifically and empirically the impact of specific animal health interventions on different stakeholders. Furthermore, while value chains provide us a potential rubric for conceptualizing the diversity of actors and impacts that could be affected by an animal disease outbreak, we are still left with the need for greater understanding of how to better align the incentives that govern these interactions. That is to say, while value chains can identify what drives incentives for different actors, based on their particular socio-economic and institutional context, it does not tell how best to align and improve incentives between actors, particularly where the number of actors is large and interactions between them is complex. Table 2 provided some speculative insights into what might enhance individual agent incentives, but we still lack a framework for guiding us on which interventions might be optimal and how those are shaped by the interactions inherent in a systems setting.

Thus, while the value chain is a necessary means of improving our knowledge of poverty impacts and the incentives behind those, it is not sufficient, with quantitative models necessary to further enhance the analysis. In this next section, we look more closely at the economics literature for guidance on modeling incentives more directly.

4. From value chains to incentives: how do we align incentives for sustainable control?

Incentives are an integral component of economic behavior. Much of why economic agents behave in the way that they do revolves principally within an internal benefit-cost calculation; that is, do the benefits resulting from a particular option exceed their costs? The economics literature is replete with many examples of assessing the role of incentives in behavior and even has a sub-field (sometimes referred to as “information economics”) that specializes in such issues. A related strain of literature is what is referred to as the New Institutional Economics (NIE) that focuses on the role of public and private institutions in correcting market failures and externalities that arise in certain transactions (see Rushton et al., 2007 for an excellent review of this literature in an animal health context). Holden (1999), Leonard (2000) and Ahuja (2004) highlight the importance and role of NIE in the provision of animal health services and planning. Our focus in this section is on micro-level decision-making rather than institutions per se.

A workhorse of the information economics literature is the principal-agent model (Laffont and Martimort, 2002). In its simplest form, the idea behind this model is that a principal (such as a boss or manager of a firm) is assigned with delegating a task to an agent (such as an employee). Both the principal and agent have different objectives: the principal wants the agent to work hard so as to boost company performance, while the agent has a disincentive to work hard unless he is properly compensated for it. Where perfect information exists between both parties, the principal can design a wage contract to induce the agent to exert the optimum amount of effort such that the prin-
principal’s objectives are met. However, it is often the case that the agent has private information that is unknown or unobserved ex ante by the principal. The situation of moral hazard exists when the principal cannot verify ex ante the actions taken by the agent. An example of moral hazard could include a labor contract, where the principal cannot directly observe the effort made by the contracted employee. An adverse selection problem arises when the principal cannot verify ex ante specific characteristics about the agent (for example, in terms of their quality); insurance markets are an example of this in which the insurance company does not know beforehand attributes of potential clients that might make them more or less susceptible to accidents (Macho-Stadler and Perez-Castrillo, 2001). A third type of problem addressed in this literature is signaling models whereby an agent will signal information to the principal in order to enhance the contract received by the agent. Examples of this include job markets in which candidates try to reveal extra information about their education or skills to afford themselves an advantage.

Animal health issues are generally not explicitly characterized in an information economics setting. Rather, incentive issues are typically handled from the standpoint of an individual producer or from the perspective of a “social planner,” either of whom chooses production practices to maximize their income or welfare subject to various constraints related to production costs, government policies, and/or biological attributes of the disease (Bicknell et al., 1999; Stott et al., 2003; Horan and Wolf, 2005; Stott et al., 2005; Hennessy, 2007; Horan and Fenichel, 2007). A recent exception to this is Gramig et al. (2009). In this paper, the authors couch animal disease issues both from the standpoint of moral hazard (i.e., ex ante actions taken by producers in biosecurity measures) and adverse selection (i.e., ex post reporting of infections). In particular, the authors note that public policy tends to rely on compensation for culling animals to induce both improved biosecurity practices and reporting when disease outbreaks take place. While their analysis is highly theoretical, an important implication of their stylized model is their finding that multiple mechanisms are required to deal with both moral hazard and adverse selection problems to induce compliance with animal disease control practices.

Most of the economic papers in this theme tend to be rather theoretical and stylized, with limited empirical support given to the conclusions derived; Bicknell et al. (1999) and Stott et al. (2003, 2005) are exceptions in this regard. Such models typically do not delve into the nature of interactions within and between multiple actors, other than a “principal” (often “government”) and an agent (often an individual producer). Multi-agent models are present in the theoretical information economics literature (Lazear and Rosen, 1981; Holmstrom, 1982; Green and Stokey, 1983), but these have neither been applied in an animal health setting nor are they complex enough to handle large value chain systems. A further critique of these models is that, while a number of these papers attempt to explicitly characterize epidemiological phenomena, particularly with respect to the spread of disease, complete integration of the economics with the epidemiology in terms of the evolution of disease, response, and behavior is limited. Rich (2007) is highly critical of a number of the assumptions made in current theoretical economic models of animal disease, noting first that such models do not address the influence of animal disease on the dynamics and evolution of the livestock production cycle. This is important since such cycles strongly influence the marketing behavior of producers and can influence the evolution of disease itself. Second, and related to the first point, price effects tend to be absent or assumed exogenous (i.e., predetermined) in all of these models. However, price signals represent powerful sources of information for producers and other stakeholders and are a strong driver of behavior from the standpoint of economics and the epidemiology of disease. Price spikes or falls that occur because of an animal disease will have ramifications on decisions made for the future, which in turn could influence how a disease spreads in the present and beyond. Third, theoretical models make extremely strong assumptions about agent behavior, generally assuming that agents have perfect information about the environment in which they operate. Such information may be asymmetric between parties (Gramig et al., 2009), but agents themselves are assumed to be rational and imbued with perfect information. In reality, however, agents might actually be what is termed as “boundedly rational”: they make their decisions in a more nuanced, intuitive manner based on past actions and what others around them do (Young, 1998). This is particularly salient in the developing world where “optimizing” behavior by poor producers and pastoralists may run contrary to economic principles and embody a range of economic and non-economic considerations. A final critique by Rich (2007) is that current theoretical models mostly incorporate optimal control techniques that derive steady-state solutions rather than characterize the dynamics of the disease. This contrasts with quantitative epidemiological models of disease spread which typically have no closed form solution and emphasize instead the nature of disease dynamics and policy options that might influence its spread. At the end of the day, the information economics literature provides a piece of the puzzle: insights into how incentive mechanisms could be designed, but such insights remain incomplete in the presence of the complex interactions that exist in livestock value chains. How we bridge that gap and integrate value chain analysis with the rich insights of information economics is the topic of the next section.

5. Next steps: how to operationalize bottom-up approaches for policy

Both value chain analysis and information economics hold particular promise and relevance towards impact assessments that are more robust and thorough than past ones, particularly in the context of the roles of incentives. Both methods stress a bottom-up perspective on the role of individual actors in defining macro-level behavior that is missing in many of our “big” models, whether from the standpoint of epidemiology, economics, or both. They further give context to what drives behavior—why do different actors behave as they do based on their socio-economic and institutional setting and the interactions of such actors with
others. Nonetheless, we still lack two crucial insights. First, and most important, can we conceive of analytical methods that are powerful enough to address the complexity of stakeholders and interactions inherent in livestock value chains? Do such methods exist and how can economists and epidemiologists work together to contribute in this area? Second, and fundamental to the first, concerns the issue of data. What types of data resources are required to support such new thinking on impact assessments and to what extent is such data available or feasible to collect?

With respect to the first issue, Rich (2007) suggests that truly integrated epidemiological-economic models must incorporate feedback effects that demonstrate the influences of disease dynamics on behavior and incentives and vice versa. In his paper, he develops a simple modeling framework that integrates the epidemiology of disease spread with a model of a producer behavior using system dynamics tools that explicitly link disease evolution with producer decisions to market, hold, or breed animals (Sterman, 2000). Simulation models such as these, or those utilizing agent-based methods hold particular promise by providing a bottom-up approach to characterize and overlay the interaction of economic and epidemiological agents and their behavior (Schelling, 1971; Berger, 2001; Berger et al., 2006; Happe et al., 2006). However, these models are relatively new to both the epidemiological and economics literature, with only a very small subset of researchers employing such techniques and almost none applying these to animal health issues. Furthermore, most epidemiologists and animal health economists lack training or background in such tools, and so mainstreaming these techniques in impact analysis will require a steep learning curve. Having said that, a major need in integrating epidemiology and animal health economics is in methods development. Too much time is spent on applying existing (often dated) techniques to different issues or diseases, despite the fact that there is sometimes a dissonance between what we can provide and what policymakers (and stakeholders in the value chain) require from us as researchers. Perhaps the bridge that is required to truly link animal health economics with epidemiology is in such model development: the construction of bottom-up models that directly integrate behavior with disease. The developing world provides an extremely fruitful laboratory for such models, given the policy needs for pro-poor impact assessments, the large diversity of stakeholders in developing country value chains, and the potential that such analyses could have to improve the role of livestock as a pathway out of poverty.

Regarding the issue of data, there are several options, some established and some emerging. We are talking of acquiring data from a framework of actors historically not approached, and furthermore a type of data, on incentives, not usually collected from any set of actors contributing to traditional animal health information systems. Animal information systems in many developing countries have arguably been in decline for some time, and have also struggled to involve the poorer sectors of society. Faced with the need for alternative options to the decaying public sector animal health information systems reliant upon passive surveillance in underfunded veterinary services, an Expert Panel on Animal Health Information Systems in Developing Countries convened by FAO advocated the strategic use of structured active sample surveys and studies (FAO, 1995). Subsequently there has been a plethora of studies emerging on specific diseases and constraints, but generally funded by specific projects rather than being part of an institutional framework. While that is not ideal, it perhaps represents a pragmatic approach to data collection, an area that is acknowledged as fundamental, but one that is difficult to move up the funding priority listings in most developing countries.

Recently emerging has been the concept of participatory disease surveillance (Catley and Leyland, 2001; Allport et al., 2005; Catley, 2006; Jost et al., 2007), engaging some of the actors critical in value chain analysis (but mostly at the producer level), and providing an approach that can readily be moulded to other actors. These tools build on the participatory rural appraisal (PRA) tools used to gather dynamic data from communities neglected by many national data systems (e.g., Krishna et al., 2004; Kristjanson et al., 2004). It has been argued that these tools allow greater precision in the dissection of the dynamics of issues at the community level, which have historically been captured by panel data from censuses, but these are clearly conducted at a very broad level. An evolving institutional option is in the form of the World Bank’s Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) program, which is undergoing a new phase of activity with funding from the Bill and Melinda Gates Foundation (BMGF). This program arose from the need to improve statistical data at the household level required for designing, implementing, and evaluating social and economic policy in developing countries. The focus of the LSMS programme has been on understanding, measuring and monitoring living conditions, the interaction of government spending and programmes with household behavior, ex ante and ex post assessments of policies, and the causes of observed social sector outcomes. The resulting LSMS surveys use multiple survey instruments to obtain data needed for these purposes and rely on significant quality control mechanisms to ensure high-quality, relevant data.

The LSMS-ISA offers a unique opportunity to collect in a systematic and detailed manner data on livestock at the household level, and to track changes that occur over time. It also allows the relative value and dynamics of livestock’s contribution to livelihoods to be understood in relation to other livelihood sources, for example to answer questions such as, is livestock becoming more or less important for the poor relative to other livelihood options?

LSMS-ISA builds on more than 20 years experience acquired conducting multi-topic LSMS panel surveys. It is a new initiative, funded by BMGF, under which the World Bank is supporting seven African countries (Tanzania, Uganda, Ethiopia, Malawi, Mozambique, Niger and Nigeria) to generate household panel data with a strong focus on agriculture. It is intended that households will be revisited every three years to track change (depending on funding, in some countries it may be annually). The LSMS-ISA is collecting data on household demographics, education, health and nutrition, food consumption/expenditures, non-food expenditures, dwelling conditions, assets, employment,
agriculture and livestock, internal and international migration, participation in projects and programs, and non-farm self-employment and other sources of income. Information is being collected in a manner that allows for gender-disaggregated analysis. The LSMS-ISA initiative has already begun in Tanzania and will be progressively rolled out in the other countries by 2011. Between 3000 and 5000 households will be sampled per country. The LSMS-ISA already includes some livestock questions in the panel surveys; currently in the agriculture module this includes inventories of livestock by species and where appropriate sex, and differentiates between traditional/improved breeds; births, deaths, slaughter and sales of live animals; inputs including labor and fodder; losses due to animal disease and theft; vaccination; and production and sales of livestock products. Within the crop-based sections, some information can be gleaned on usage and sales of ‘organic fertilizer’ (which could include manure) and production and sales of crop by-products (which could be fed to livestock). The LSMS-ISA initiative is very amenable to evaluating innovations. This potentially allows for an understanding of the impacts of employment or livelihood crises, such as those caused by animal diseases, on any household, whether primary livestock producer or other value chain participant, and even offers the potential for periodic and more specific disease inquiries targeted at population samples. Under BMGF funding it is currently planned to conduct baseline LSMS-ISA panel surveys in seven countries between 2009 and 2011 (World Bank, 2010)4. The countries to be included are Tanzania (where the survey is currently underway), Uganda, Ethiopia (2011), Malawi (2009), Mozambique (2010), Nigeria (soon), Niger (2010).

At the end of the day, a fundamental need will be the change in mindset necessary to incorporate bottom-up approaches in animal disease impact studies. In many respects, a significant portion of epidemiological research and modeling efforts already examine diseases at a micro, bottom-up level, highlighting the evolution of disease among affected herds in discrete regions. What is needed to value-add such research, particularly (but certainly not exclusively) in a developing country and poverty context, is to contextualize those biological drivers in their socioeconomic and institutional setting, paying close attention to the interactions and feedbacks between disease and behavior. Our challenge as economists is to work much more closely with epidemiologists in this regard, stressing behavior and incentives as our contribution in understanding the complex and nuanced impacts that animal diseases produce.

6. Conclusions

We present the argument for much greater dissection of the different impacts of livestock diseases on developing country societies, in order to build a greater understand-


ing of both the full impacts of diseases, and also of the impacts of, and opportunities for, sustainable mitigation interventions. Central to this is greater use of a value chain approach, identifying key actors and developing a greater understanding of their incentives to participate in mitigation interventions. We highlight the issues affecting different value chain actors, and draw attention to examples of new tools that put greater emphasis on the “bottom-up” approach necessary to gain fuller understanding and appreciation of disease impacts.

Conflict of interest statement

None of the authors (Karl M. Rich, Brian D. Perry) has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the paper entitled “The economic and poverty impacts of animal diseases in developing countries: new roles, new demands for economics and epidemiology”.

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