Are Disease Equilibria Equivalent to Health Equilibria?

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INTRODUCTION

- Health of either a human or an animal is susceptible to a myriad of infectious and noninfectious diseases, as well as injuries (Rushton et al., 2018, 2021).
- In a human health setting this can be illustrated by a mapping of many diseases to a single measure of health (e.g., disability adjusted life-years or DALYS).
- In a farmed animal health, in contrast, life-years are dictated by the market based on the profit metric (Hennessy and Marsh, 2021).

MOTIVATION

- Mapping of many diseases to a single measure of health by linearly aggregating outcomes of single diseases can lead to double or over counting and other measurement errors.
- From an economic perspective, improvements in health not only can improve the well-being of households but can also alter or distort market prices in an economic sector or sometimes impact a countries economy as a whole (Hennessy and Marsh, 2021).
- While traditional disease models often assume fixed prices in equilibria, in contrast, health equilibria naturally reflect adjustments of markets (prices and quantities) in partial equilibrium or general economic equilibrium settings.

OBJECTIVES

- The aim of this study is to formulate and then delineate between disease equilibria and health equilibria on an economic landscape. Most particularly we focus in on changes in health outcomes and not simply output changes due to a single disease, which is relevant in both the human and animal context.
- We focus and identify economic equilibria for health that can be extended to zoonotic diseases that overlap human and animal health.
- Finally, we discuss metrics for measuring health improvement. For an illustration, and empirical evidence, we present results from a case study(s). Most specifically, for Ethiopia, we examine the impacts of improvements of animal health (e.g., small ruminants) on its economy and the impacts on consumers and producers.

METHODOLOGY

- Hennessey and Marsh (2021) define a health loss function in a production technology, which has antecedents in the crop loss literature (Marsh et al. 2000), ranging from zero loss to total loss.
- Incorporating the above production technology into behavioral equations of a partial equilibrium model or general equilibrium model allows one to capture changes in inputs and outputs - translated into demand and supply equations at different market levels - from the current health state to different health equilibriums in an economy.
- Empirically, mapping diseases and injuries into a single measure of health loss can be generated through epidemiological modeling of an animal health envelope (Rushton et al, 2018, 2021). This approach captures a total health hazard, and then attributes out this total among the individual hazards avoiding double or over counting (Rushton et al, 2018, 2021).

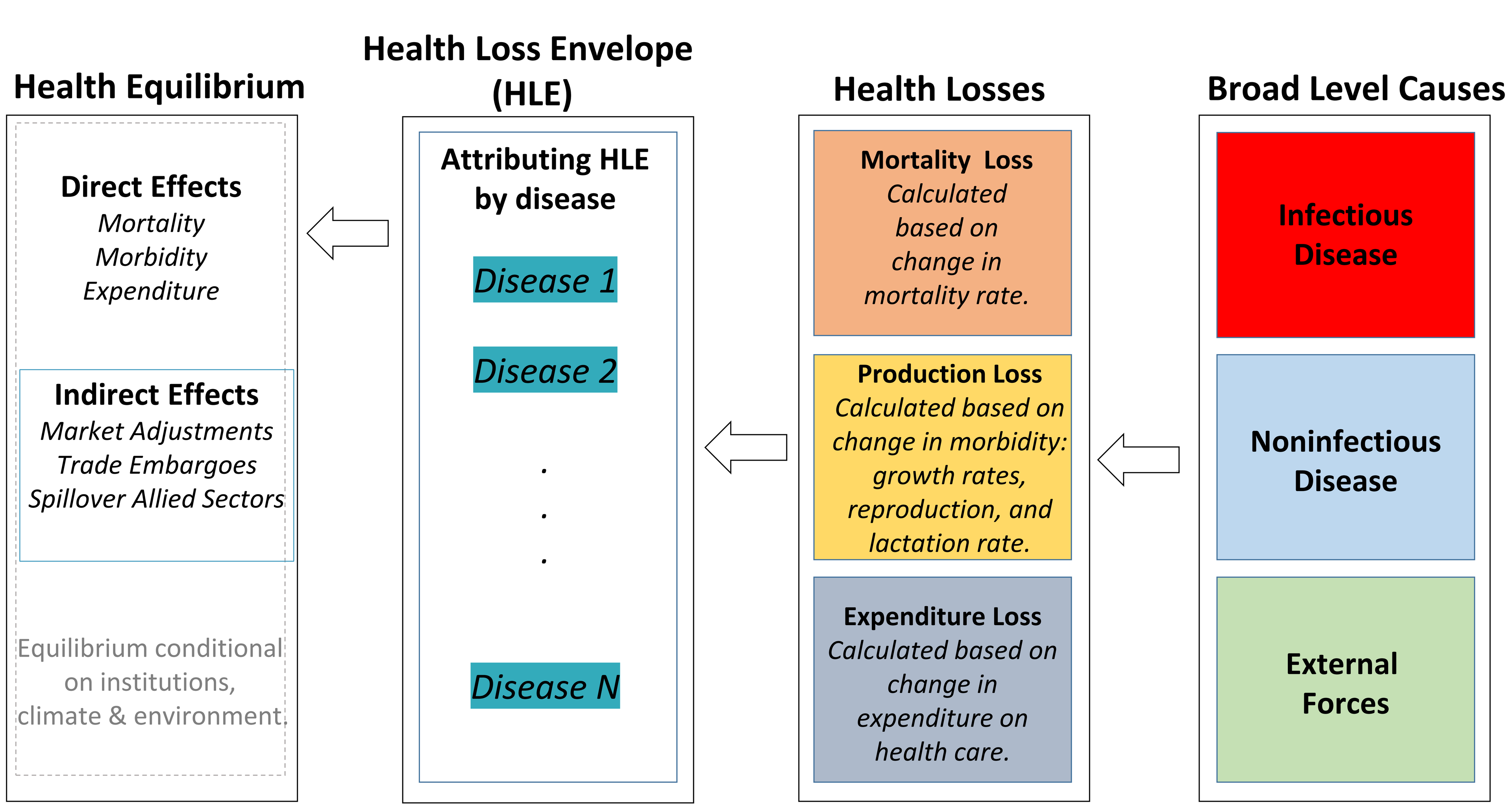

Figure. Mapping Diseases & External Forces into Health Equilibrium

CASE STUDY - ETHIOPIA

- We apply a vertically integrated partial equilibrium model to identify and to assess how changes in livestock disease and animal health impact input-output markets and the economy of Ethiopia, wherein many livestock diseases are endemic.
- Economic welfare measures of changes in health hazards can be captured through use of consumer surplus, producer surplus, and asset loss to assess the distribution of health burden (Hennessy and Marsh, 2021).
- Therefore, metrics of economic welfare are translated through market outcomes and are used to identify the distribution or redistribution of wealth for changes in animal health to inform policymakers and other stakeholders.
- We specify potential structural changes in both input for live animal production and output markets (domestic and international) of meat supply to recognize the impact of animal health on upstream live animal production and on downstream output markets of processing and eventually retailing through consumer demand.
- We have used equilibrium displacement model (EDM) by taking total logarithmic differentials of the behavioral functions. The resulting model comprises of 24 elasticities (parameters of the EDM) and 22 endogenous variable.

DATA AND SCENARIOS

- To calculate a baseline and changes in economic surpluses, we collect the data from FAO stat and from an epidemiological model of Global Burden of Animal Diseases (GBADs) program.
- For the first scenario, we consider negative shifts in meat supply and then observe responses along the supply chain. This is a scenario to examine, say, a single or multiple disease outbreaks.
- In the second scenario, we consider positive shifts in live animal production, for the intermediate to long run, and then observe responses along the supply chain. This scenario reflects animal health improvements as a whole, and not improvements by individual diseases.

SIMULATION RESULTS

- In the table below we present illustrative results conditional on parameterization of the model. For the first scenario, we observe that negative shifts of meat supply have a negative impact on consumers and processors but a positive impact on live animal producers (due to higher prices). For the second scenario, we observe that positive shifts in live animal production have a negative impact on live animal producers (from oversupply) and processors but a positive impact on consumers (due to lower prices). Total surplus remains negative for both scenarios.

Scenario Description	Supply Shift	Live Animal PS	Meat PS	Consumer Surplus	Total Surplus
Supply shift on meat supply	-5%	14.07	-34.44	-35.92	-56.29
	-10%	28.32	-67.68	-70.69	-110.05
	-15%	42.74	-99.73	-104.31	-161.30
Supply shift on live animal productivity	5%	-9.06	-121.47	34.43	-96.11
	10%	-18.50	-246.74	69.85	-195.39
	15%	-28.31	-375.80	106.26	-297.84

Table: Welfare changes (in mill USD) in response to shifts along the supply chain.

- In-so-far-as positive shifts of live animal production represent improvements in animal health (from a collection of diseases), then the health equilibria outcomes represent an aggregate impact of disease and external forces on economic welfare (including an equilibrium of no health loss).
- Changes in health equilibria (due to changes in prices and quantities) allows for measuring welfare changes at different stages of supply chain. An observation is that welfare changes are not uniformly distributed along the value chain, but rather are heterogeneous in nature.
- Another observation is that welfare changes are not symmetric across the negative/positive shifts in the two scenarios, but rather asymmetric as exhibited in the surplus of meat processors. The upshot here is that positive health equilibria can be distinct from negative disease equilibria.
- From a broader perspective, policies or regulations designed for welfare neutrality and welfare improvement should consider not only total welfare, but also welfare of producers, processors and consumers individually.

CONCLUSIONS

- Global health is front and center in science and policy, especially given the recent waves of COVID-19. As well, in livestock and wildlife, African swine flu (ASF) and highly pathogenic avian influenza (HPAI) is currently sweeping across the globe.
- Economist have important contributions to move metrics and measures away from disease centric analysis to health centric analysis, when assessing the impacts of societal changes in health across the globe.
- There are limitations to this research. For example, as we do not incorporate companion animals or wildlife.

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