A common thread throughout the majority of my work is the use of interdisciplinary modeling, connecting economics, natural sciences, and public policy. My first publication came out of my PhD dissertation and was inspired by research in theoretical biology. The paper used refinements of the methodology introduced by John Maynard Smith in Evolutionary Game Theory to study how a coordination failure leading to financial contagion can spread.\(^1\) I have since continued to develop game-theoretic models of contagion,\(^2,3\) more recently in the context of zoonotic disease transmission. Early in my career, I received a *National Science Foundation* grant to study the design of market trading mechanisms that optimally explore the trade-off between risk and efficiency. This has led to a number of methodological contributions in the study and design of exchanges and markets.\(^4,5,6\) One focus of my ongoing research is on the economics of emerging infectious diseases. This includes upstream issues, such as the effect of deforestation and environmental degradation to zoonotic disease emergence, as well as downstream issues, such as the mitigation of the disease once it emerges. I briefly elaborate on some related research projects in what follows.

Several studies by economists combine epidemiological and macroeconomic modeling in order to understand the possible tradeoffs between public health and economic performance during a pandemic. Standard macroeconomic models, however, abstract from the network through which economic transactions take place. Simulations done by epidemiologists using standard SIR-based modeling consider the networks resulting from individual interactions. However, epidemiological studies often ignore economic incentives and treat the individuals’ decisions as random and exogenous. Typically, workers need to participate in certain activities that bring them in the proximity
of others in order to create economic value. Due to agglomeration externalities, higher productivity results in higher economic value created in areas involving higher population density. At the same time, commuting and working in the midst of larger groups implies a higher risk of disease transmission. Taking these factors into consideration, workers might choose to stay home, engage in less risky (but also less productive) activities, or risk commuting to locations where economic rewards (and health risks) are higher. Their preferred actions will depend on the actions of the other workers, as summarized by the aggregate state in the economy. My ongoing work combines recent developments in game theory together with epidemiological modeling to study the economic choices of individuals in large populations during different phases of a pandemic and as a function of different characteristics of the pathogen. As individual incentives do not fully internalize the costs resulting from disease transmission, the resulting network will fall short of being optimal. The role of policy then becomes to design the rules of this game so that optimization by individuals given these rules will lead them to choices that will move the network towards the efficient frontier. I am currently working with an interdisciplinary team to develop dynamic strategic quantitative models that incorporate these factors, assess the resulting tradeoffs, and make corresponding policy recommendations to efficiently explore the tradeoff between economic benefits and health costs.

In current ongoing work with the World Bank, I am exploring novel ways to incorporate ecosystem services to macroeconomic models commonly used for policy evaluation by governments. Our approach attempts to construct global indices of the social cost of deforestation that incorporate the economic costs resulting from risks to human health. These include pathogen emergence and disease outbreaks, reduced water quality, and loss of potential biomedical compounds. There is evidence linking the emergence and frequency of pandemics like Covid-19, as well as the incidence of vector borne diseases, to deforestation and climate change. Developing communities around the world are also disproportionately exposed to the effects of air pollution, extreme
Part of my work documents the effects of environmental inequality and outlines strategies for reducing their impact on human wellbeing. In a recent paper, I employed county-level data in the state of Texas to investigate the correlations between racial composition, exposure to local pollution (as measured by historical PM$_{2.5}$ concentrations) and the effects of Covid-19. Using the value-of-statistical-life as an indicator of economic costs, this work confirmed that the economic effects of Covid-19 in Texas have been disproportionally borne by African American and Hispanic communities. In a related project, I studied the connection between commuting and Covid-19 incidence in the major US metropolitan areas. The study identifies important regularities related to disease incidence that go beyond the known effects of population density. Low-income workers, many of whom cannot work remotely, often have little choice other than using public transport to commute to work. This, in turn, correlates with a higher incidence of disease transmission and disproportionally affects economically vulnerable communities, exacerbating problems related to environmental and health inequality. The modeling involves a choice of means of transport when value-of-time and value-of-safety from possible disease transmission both play a role in the commuters’ decisions. Any significant switch toward private transport would have implications for energy demand, congestion and higher emissions. Since Covid-19 is not the last pandemic that will affect the US, these findings point to an urgent need for the design of equitable and effective transport systems that take the presence of infectious disease into consideration. More recently, in joint work for the World Bank, I investigate the effects of pollution on human health and labor productivity in areas near fossil-fuel power stations in Chile.

Another main component of my recent work investigates several aspects of the energy-climate-economics nexus in connection to the optimal energy transition. Some of my findings highlight that in the presence of uncertainty about the effects of anthropogenic climate change, policy must be more cautious than in situations where we face smaller and better-understood risks. To capture the need for resilience in the
presence of uncertainty, my work employed modeling from robust control.\textsuperscript{14} This allowed for the derivation of efficient policies that are also robust to a variety of scenarios, including worst-case ones. One finding from this research is that the level of the carbon tax ought to be at least an order of magnitude higher than the one prescribed by standard integrated assessment models.\textsuperscript{15} I am currently extending these models to incorporate game-theoretic aspects arising in \textit{international climate negotiations}. These models take into account both the role of climate uncertainty and the fact that climate change is likely to have diverse effects across different regions.

A third research focus concerns how economic principles and modeling can be used to understand biological interactions. There is a large intersection between Ecology and Economics. For example, Ecological Economics argues that Economics should incorporate principles from Ecology and explicitly take into account that economic activity takes place in the biosphere. There is however another, less visited part of this intersection between the two fields. Economics provides a set of tools to study the principles behind production, exchange, and consumption of scarce resources. These principles apply regardless of whether participants are humans, or other species of animals or plants. An example of this “Economic Ecology” approach is the study of \textit{biological markets}, where resources are exchanged between different organisms. Biologists commonly interpret these interactions as symbiotic mutualisms, and often model them using a hybrid of game-theoretic and informal market concepts. Using data from ecological experiments, I studied the exchange rates of phosphorus traded for carbon between mycorrhizal fungi and their host plants. This work demonstrated that Walrasian equilibrium, a leading paradigm in Economics, can be used to model biological interactions.\textsuperscript{16} Far from being altruistic, organisms such as fungi can exhibit competitive behavior similar to that in markets involving sophisticated human participants. This finding also implies that the resulting allocation of resources is efficient for the ecosystem taken as a whole. Arbuscular mycorrhizal networks around the world are estimated to sequester around five billion tons of carbon per year.
Understanding the dynamics of the fungi’s trading strategies can assist in the overall evaluation of the carbon-capture potential in soils. In addition, manipulating these exchange rates so that more carbon is exchanged for nutrients could have a significant potential for expanding carbon-capture. I continue to investigate the economic principles behind symbiotic relationships in biology.

In a different context, my work employed mechanism design to propose policies that address externalities related to emissions\textsuperscript{17} and conservation.\textsuperscript{18} In developing countries, farmers often face the risk of losing a significant fraction of their wealth as a result of attacks from endangered wildlife. Using data from Project Snow Leopard, a pilot insurance scheme in the village of Skoyo in Pakistan, I demonstrated that livestock insurance can improve the well-being of livestock owners and may also reduce related preemptive killings of large carnivores, such as the snow leopard. The optimal insurance contract optimizes the trade-off between risk sharing and conservation. Related insurance schemes are relevant towards implementing conservation goals in cases where livestock or agriculture suffer damages from wildlife. Examples include the reintroduction of wolves in parts of North America, the conservation of elephants and large predators in Africa and Asia.

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\textsuperscript{1} T. Temzelides “Evolution, Coordination, and Banking Panics,” \textit{Journal of Monetary Economics} \textbf{40} (1997)
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