Fall 2023

Dr. Ziwei Ma, Assistant Professor

- **Date:** Friday, Sept. 29, 2023
- **Title**: Estimation for Skew-Normal Based Stochastic Frontier Model
- **Time:** 3:00pm
- **Location:** Lupton 393
- **Abstract:** Stochastic frontier models (SFMs) are popular econometric models for estimating the production frontier and measuring the technical efficiency of a firm. The classical SFM proposed using a normal distribution for the noise term $V_í$=V_i and a half-normal distribution for the one-sided inefficiency term U_i=U_i (Aigner et al. 1977; Meeusen and van Den Broeck 1977). Since the classical SFM suffers from the "wrong skewness" issue, leading to estimating full efficiencies of all firms in applications. Recently, Wei et al. (2021) proposed the skew-normal/half-normal SFM (SN-SFM) which provides a solution to the "wrong skewness" issue. In this talk, the basics of SFM and SN-SFM will be briefly introduced. Then the estimation approach for SN-SFM using the expectation conditional maximization algorithm is developed which outperforms the numerical MLE algorithm in both comprehensive simulation study and real data analysis. In the end, several potential directions of further improvement will be discussed.

Dr. Xiunan Wang, Assistant Professor

- **Date:** Friday, Oct. 6, 2023
- **Title:** From HIV to SARS-COV2: Mathematical Modeling of Viral Dynamics
- **Time:** 2:30PM
- **Location:** Lupton 393
- **Abstract:** In this presentation, we delve into the field of viral dynamics modeling within two distinct contexts: HIV and SARS-CoV-2. First, we investigate an HIV experiment that showcases the effectiveness of vectored immunoprophylaxis. Utilizing mathematical modeling, we unveil the concept of a backward bifurcation and explore its far-reaching implications. Additionally, we dissect the intricate interplay between antibodies and the virus, revealing a world of complex dynamics, including bistable behavior. Shifting our focus to SARSCoV-2, we introduce a reaction-diffusion model that characterizes viral infection within a heterogeneous environment. Our discussion encompasses the profound impact of diffusion, spatial heterogeneity, and incidence types on SARS-CoV-2 infection dynamics. This presentation provides a valuable opportunity for both students and mathematicians to explore mathematical modeling of viral dynamics.

Stephanie Passmore (ASA) and JB Murphy (FSA)

- **Date:** Friday, Oct. 20
- **Title:** Want to be an Actuary?
- **Time:** 2:00PM
- **Location:** Lupton 393
- **Abstract:** We will describe our individual jobs and typical day-to-day to experience. Then we will go over the Actuarial Department as a whole, emphasizing the three main areas: pricing, forecasting, and valuation. We will also talk more in depth on the topic of reserving. We will conclude with details of BlueCross' Actuarial Development Program, speaking about study hours, increased pay for passing exams, and other benefits.

Dr. David Walker

- **Date:** Friday, Oct. 27
- **Title:** Mathematical Topics in Quantum Computing
- **Time:** 2:30PM**Abstract:** Quantum information science has recently emerged as an area of significant academic and commercial interest. This talk is presents a brief introduction to quantum computing and outlines areas in which mathematics is key in delineating quantum algorithms. Of particular interest are quantum algorithms for the hidden subgroup problem (HSP) for Abelian groups, which has applications in areas such as graph theory, numerical linear algebra, number theory, and cybersecurity. Shor's factoring algorithm is a well-known example that depends on solving the HSP using a quantum algorithm. Aspects of Shor's algorithm and its application to cybersecurity will be presented. Finally, the future prospects for practical and effective quantum computers will be considered.

Dr. Satyan L. Devadoss

- **Date:** Friday, Nov. 3
- **Title:** Unfolding Regular Polytopes
- **Time:** 3:30PM
- **Abstract:** This talk is about a geometric mystery whose origins date back 500 years to the Renaissance master Albrecht Dürer, who first recorded examples of unfolded polyhedra. Recently, just a decade ago, it was shown that every unfolding of the Platonic solids was without self-overlap, yielding a valid net. We consider this property for all regular polytopes in higher dimensions, proving what works and puzzling over what doesn't. This talk is heavily infused with visual imagery.

Dr. Thien Le

- **Date:** Friday, Nov. 10
- **Title:** Connecting Epidemics on Networks and Mass-Action Models*
- **Abstract:** The Black Death and COVID-19 stand as historic and contemporary reminders of the severe impact of infectious diseases, with millions of lives lost. Epidemic modeling is crucial because it helps us forecast outbreaks, manages our response, and ultimately save lives. Even though mass-action models are widely utilized in epidemic modeling, its homogeneously mixing assumption is often violated since individuals tend to interact with a small number of other people over time. This naturally leads to network models in studying epidemics, which is especially useful for studying sexually transmitted diseases. Despite extensive research on both network models and mass-action models, the relationship between them is still not well understood. We try to bridge the gap here by presenting a spreading method on networks and then mapping its spreading process to mass-action models. The proposed method is backed up by theoretical justification and simulation studies. Our discovery could pave the way for more research into network spreading processes.
    - *Joint work with Associate Professor Jukka-Pekka Onnela, Department of Biostatistics, Harvard T.H. Chan School of Public Health, Harvard University.

Dr. Yu Jin

- **Date:** Friday, Dec. 1
- **Title:** Spatial Population Dynamics in Heterogeneous River Environments
- **Abstract:** Natural rivers and streams are important habitats for aquatic species and other species that rely on them. The study of population persistence and spread in river ecosystems is key for understanding river population dynamics and invasions as well as instream flow needs. We develop process-oriented reaction-diffusion-advection equations that couple hydraulic flow to population growth and analyze the models theoretically and numerically to assess the effects of hydraulic, physical, and biological factors on population dynamics. We present a mathematical framework, based on persistence metrics such as the fundamental niche, the source and sink metric, the net reproductive rate and the principal eigenvalue of the associated eigenvalue problem to determine local and global persistence of a population in a spatially heterogeneous one-dimensional or two-dimensional river or river network. We establish asymptotic spreading speeds to understand biological invasions in the upstream and downstream directions in temporally and/or spatially heterogeneous river environments. Furthermore, we present a hybrid modeling approach to explicitly link the flow regime with ecological dynamics, which helps analyze the impact of river morphology on population persistence in a realistic river.

Spring 2024

Dr. Lingju Kong

- **Date/Time**: Friday, Jan. 26, 2024 at 3:30 p.m.
- **Location**: Lupton 392
- **Title**: *Modeling the Dynamics of Product Adoption and Abandonment*
- **Abstract**: We introduce a new compartmental differential equation model to examine the dynamics of user adoption and abandonment within a product context. This model features a nonlinear adoption rate and encompasses two distinct abandonment dynamics: infectious abandonment stemming from interactions among current and past users, and noninfectious abandonment induced by mass media, advertisements, or the emergence of new products. Our exploration encompasses discussions on the existence and stability of model equilibria, as well as the derivation of a critical threshold quantity that regulates the model dynamics. Additionally, we establish criteria for backward and forward bifurcations and various forms of Hopf bifurcation. Detailed scrutiny of an associated optimal control problem is undertaken, starting with the establishment of the existence of an optimal control pair, followed by the determination of the requisite system conditions for this control pair. Extensive numerical simulations are conducted to validate the theoretical findings. Finally, we showcase the model's efficacy by fitting it to historical data on Facebook's daily active users, employing the derived parameter values to predict future user counts.

Yiran Wang, Ph.D.

- **Date/Time:** Thurs., Feb. 22, 2024 at 3:15 p.m.
- **Location:** Lupton 302
- **Title:** *Novel Neural Networks with Model Reduction Methods and Physics*
- **Abstract:** Many significant physical problems are described by partial differential equations (PDEs), and model reduction methods offer an effective means to decrease computational costs in numerical methods. Furthermore, neural networks, serving as a universal function approximator, hold the potential to enhance these model reduction methods. Conversely, novel neural networks designed with considerations of physics and reduced order methods can achieve notable effects. This work aims to explore the interplay among physics, model reduction, and neural networks, focusing on two key parts. Firstly, I will introduce an efficient reduced order method known as the local-global method. Based on this, I will present a natural integration of this model reduction technique with neural networks. In the second part, I will introduce a special randomized neural network, offering a general computational approach for addressing numerous nontrivial physics problems. Finally, I will discuss intriguing potential research avenues at the intersection of physics, model reduction, and neural networks.

Megan McCoy

- **Date/Time**: Friday, Feb. 23, 2024 at 3:30 p.m.
- **Location**: Lupton 393
- **Title**: *Comparison of Traditional Statistical Methods and Machine Learning Methods with Application to Early Onset Colorectal Cancer*
- **Abstract**: This study compares traditional statistical methods with machine learning techniques for predictive modeling of mortality and incident of early onset colorectal cancer (EO-CRC). Early-onset colorectal cancer (EOCRC) refers to the diagnosis of colorectal cancer in individuals under the age of 50 and it has seen an alarming rise worldwide over the past two decades. Traditional statistical methods like logistic regression and multinomial logistic regression are contrasted with machine learning based algorithms including decision trees, random forests, K-Nearest Neighbors, and neural networks. We evaluate both methodologies using datasets containing clinical and demographic variables. Performance metrics such as sensitivity, specificity, accuracy, are analyzed, considering interpretability, computational efficiency, and scalability. Preliminary results indicate that while traditional methods offer interpretability, machine learning models demonstrate superior predictive performance, particularly with complex data. They also show potential for uncovering intricate patterns and interactions among variables, enhancing prediction accuracy. This research informs the selection of analytical methodologies in biomedical research, aiding the development of effective predictive models for early onset colon cancer detection and management.

Changhong Mou, Ph.D.

- **Date/Time:** Wed., Feb. 28 at 2:00 p.m.
- **Location:** ECS 239
- **Title:** *Reduced Order Modeling in the Age of Data*
- **Abstract:** Data-driven modeling of complex dynamical systems is becoming increasingly popular across various domains of science and engineering. In this talk, I will introduce a systematic multiscale data-driven closure reduced order model (ROM) framework for complex systems with strong chaotic or turbulent behavior. I will utilize available data to construct novel ROM closure terms, thereby capturing the interaction between resolved and unresolved modes. Next, I will explain how the new data-driven closure ROM can be integrated with a conditional Gaussian data assimilation framework that employs cost-effective, conditionally linear functions to capture the statistical features of the closure terms. This leads to the stochastic data-driven closure ROM that facilitates an efficient and accurate scheme for nonlinear data assimilation (DA), the solution of which is provided by closed analytic formulae that do not require ensemble methods. It also allows the ROM to avoid many potential numerical and sampling issues in recovering the unobserved states from partial observations. Furthermore, I will introduce a hybrid DA algorithm for complex dynamical systems with partial observations. The method exploits cheap stochastic parameterized ROMs for filtering the observed state variables, significantly reducing the computational cost. It also uses machine learning to build a nonlinear map between observed and unobserved state variables, which enables the efficient computation of the ensemble members of the unobserved states. The hybrid DA algorithm is successfully applied to a precipitating quasi-geostrophic (PQG) model, which includes the effects of water vapor, clouds, and rainfall beyond the classical two-level QG model.

F. Ayça Çetinkaya, Ph.D.

- **Date/Time:** Thurs., Feb. 29 at 3:15 p.m.
- **Location:** Zoom (contact Deborah Barr for the link)
- **Title:** *An Inverse Problem for a Sturm--Liouvile Operator*
- **Abstract:** Inverse problems of spectral analysis consist in recovering operators from their spectral characteristics. Such problems often appear in mathematics, mechanics, physics, electronics, geophysics, meteorology and other branches of natural sciences. Interest in this subject has been increasing permanently because of the appearance of new important applications. For example, application of machine learning and deep learning algorithms to solve inverse problems is an active topic the latest years. Inverse problems are also important in quantum mechanics. An inverse problem in quantum mechanics is the problem of determining the potential energy of a molecule from its spectrum where the spectrum of a molecule is the set of frequencies at which it absorbs or emits light. In this talk, the requisite concepts about inverse problems will be introduced first, then a short review of results on inverse problems for Sturm—Liouville operators will be given by only describing the main directions of the theory. After that, a boundary value problem which consists of a Sturm—Liouville operator with piecewise-continuous coefficient and a boundary condition with spectral parameter will be taken into consideration. The spectral properties of the eigenvalues and eigenfunctions will be investigated. The evolution of the Weyl solution and the Weyl function will be discussed and a uniqueness theorem for the inverse problem with respect to the Weyl function will be proven.

Jonathan Stanfill, Ph.D.

- **Date/Time:** Thurs., Mar. 7 at 3:15 p.m.
- **Location:** Lupton 302
- **Title:** *Spectral Zeta Functions and Zeta Regularized Functional Determinants for Singular Sturm-Liouville Operators*
- **Abstract:** We employ a recently developed unified approach to the computation of traces of resolvents and zeta functions to compute spectral zeta functions associated with singular (three-coefficient) self-adjoint Sturm-Liouville differential expressions. We then discuss the analytic continuation of the zeta function and the zeta regularized functional determinant, illustrating what extends from a recent treatment of regular expressions and what remains open. As an application, we consider the generalized Bessel equation on a finite interval and a regularized singular problem. This is based on multiple joint works with Guglielmo Fucci, Fritz Gesztesy, Klaus Kirsten, and Mateusz Piorkowski.

Dr. Daozhou Gao

- **Date/Time:** Fri., Apr. 19, 2024 @ 2:45 p.m.
- **Location:** Zoom - email Deborah Barr for the zoom link
- **Title:** *How do changes in human movement affect disease spread?*
- **Abstract:** Driven by factors like globalization, urbanization, and transport development, human travel has undergone significant changes in frequency, distance, means, and purpose. An adverse consequence of these changes is that they facilitate the spread of infectious diseases and pose a serious challenge to disease elimination. It is common to use patch models to describe disease spread in a discrete space. The basic reproduction number R0 can typically determine disease extinction or peristence, whereas it cannot measure the disease prevalence (proportion of people being infected). In this talk, based on a susceptible-infectious-susceptible (SIS) patch model with standard incidence, I will explore the influence of dispersal intensity and dispersal asymmetry on the disease persistence (measured by R0) and disease prevalence, respectively. Our study highlights the necessity of evaluating control measures with other quantities besides the basic reproduction number.