PAUL SANGREY
sangrey.io
PAUL@SANGREY.IO

UNIVERSITY OF PENNSYLVANIA

Placement Director: Guillermo Ordonez	ORDONEZ@ECON.UPENN.EDU	215-898-1875
Placement Director: Andrew Postlewaite	APOSTLEW@ECON.UPENN.EDU	215-898-7350
Graduate Student Coordinator: Gina Conway	GNC@SAS.UPENN.EDU	215-898-5691

Office Contact Information:
Department of Economics
University of Pennsylvania
The Ronald O. Perelman Center for
Political Science and Economics, Room 628
133 South 36th Street
Philadelphia, PA 19104-6297
267-928-8685

Personal Information:
Born: July 29, 1992
Citizenship: United States
Languages: English (native)

Undergraduate Studies:

B.S., Mathematics and Economics, Grove City College, *summa cum laude*, 2013

Masters Level Work:

A.M., Economics, University of Pennsylvania, 2015

Graduate Studies:

University of Pennsylvania, 2013 to the present
Thesis Title: *Uncertainty and Learning in Dynamic Financial Econometrics*
Expected Completion Date: May 2019

Thesis Committee and References:

Francis X. Diebold, Advisor
Department of Economics
University of Pennsylvania
The Ronald O. Perelman Center for
Political Science and Economics, Room 607
133 South 36th Street
Philadelphia, PA 19104-6297
FDIEBOLD@UPENN.EDU

Frank Schorfheide, Advisor
Department of Economics
University of Pennsylvania
The Ronald O. Perelman Center for
Political Science and Economics, Room 621
133 South 36th Street
Philadelphia, PA 19104-6297
SCHORF@SSC.UPENN.EDU

Amir Yaron
Department of Finance
The Wharton School
University of Pennsylvania
Steinberg Hall - Dietrich Hall, Room 2325
3620 Locust Walk
Philadelphia, PA 19104-6367
YARON@WHARTON.UPENN.EDU

Xu Cheng
Department of Economics
University of Pennsylvania
The Ronald. O. Perelman Center for
Political Science and Economics, Room 620
133 South 36th Street
Philadelphia, PA 19104-6297
XUCHENG@UPENN.EDU

Research and Teaching Fields:

Primary fields:	Econometrics, Financial Economics
Secondary fields:	Data Science, Machine Learning, Big Data

Teaching Experience:

Spring 2018	International Economics, University of Pennsylvania, instructor
Summer 2016	International Economics, University of Pennsylvania, instructor
Spring 2016	Introduction to Econometrics, University of Pennsylvania, recitation instructor for Professor Francis X. Diebold
Fall 2015	Introduction to Econometrics, University of Pennsylvania, recitation instructor for Professor Xu Cheng
Spring 2015	Introduction to Econometrics, University of Pennsylvania, recitation instructor for Professor Francis X. Diebold
Fall 2014	Introduction to Microeconomics, University of Pennsylvania, recitation instructor for Rebecca Stein

Research Experience:

Fall 2016 – Fall 2017:	University of Pennsylvania, Research Assistant for Professor Jesús Fernández-Villaverde
Summer 2015 – Spring 2016:	University of Pennsylvania, Research Assistant for Professor Frank Schorfheide

Professional Activities:

Presentations:

2018	The Wharton School	Finance Seminar
2018	University of Pennsylvania	Econometrics Seminar
2018	University of Chicago	Society of Financial Econometrics Summer School
2018	Stanford University	NBER-NSF Seminar on Bayesian Inference in Econometrics and Statistics
2018	George Washington University	Student Research Conference
2018	The Wharton School	Finance Lunch Seminar
2017	Yale University	Young Economists Symposium
2014, 2015,..., 2018	University of Pennsylvania	Econometrics Lunch Seminar

Referee Activity

International Economic Review
Quantitative Economics

Honors, Scholarships, and Fellowships:

2018	University of Pennsylvania, SAS Dissertation Completion Fellowship
2013	Institute for Humane Studies, Humane Studies Fellowship
2013	Grove City College, Franklin C. Ketler Mathematics Prize

Computational Skills:

Python, C++17, R, MATLAB, OpenMP, Git, LaTeX

Python Packages Published at Anaconda.org:

arma_wrapper	Provides wrapping code to use the C++ library Armadillo in Python extensions
bayesiankalman	Provides a computationally efficient Bayesian Kalman filter and smoother
cdpm	Provides estimators developed in "Bypassing the Curse of Dimensionality: Feasible Multivariate Density Estimation"
laplacejumps	Provides algorithms to estimate and forecast jump volatility and the other quantities of interest in "Jumps, Realized Density, and News Premia"
volpriceinference	Provides estimators used in "Identification Robust Inference for Risk Prices in Structural Stochastic Volatility Models"

Research Papers:

Jumps, Realized Densities, and News Premia (Job Market Paper)

Announcements and other news continuously barrage financial markets, causing asset prices to jump hundreds of times each day. If price paths are continuous, the diffusion volatility nonparametrically summarizes the return distributions' dynamics, and risk premia are instantaneous covariances. However, this is not true in the empirically-relevant case involving price jumps. To address this impasse, I derive both a tractable nonparametric continuous-time representation for the price jumps and an implied sufficient statistic for their dynamics. This statistic — jump volatility — is the instantaneous variance of the jump part and measures news risk. The realized density then depends, exclusively, on the diffusion volatility and the jump volatility. I develop estimators for both and show how to use them to nonparametrically identify continuous-time jump dynamics and associated risk premia. I provide a detailed empirical application to the S&P 500 and show that the jump volatility premium is less than the diffusion volatility premium.

Bypassing the Curse of Dimensionality: Feasible Multivariate Density Estimation

with Minsu Chang, PhD Candidate, University of Pennsylvania

Most economic data are multivariate and so estimating multivariate densities is a classic problem in the literature. However, given vector-valued data — $\{x_t\}_{t=1}^T$ — the *curse of dimensionality* makes nonparametrically estimating the data's density infeasible if the number of series, D, is large. Hence, we do not seek to provide estimators that perform well all of the time (it is impossible), but rather seek to provide estimators that perform well most of the time. We adapt the ideas in the Bayesian compression literature to density estimation by randomly binning the data. The binning randomly determines both the number of bins and which observation is placed in which bin. This novel procedure induces a simple mixture representation for the data's density. For any finite number of periods, T, the number of mixture components used is random. We construct a bound for this variable as a function of T that holds with high probability. We adopt the nonparametric Bayesian framework and construct a computationally efficient density estimator using Dirichlet processes. Since the number of mixture components is the key determinant of our model's complexity, our estimator's convergence rates — $\sqrt{\log(T)}/\sqrt{T}$ in the unconditional case and $\log(T)/\sqrt{T}$ in the conditional case — depend on D only through the constant term. We then analyze our estimators' performance in a monthly macroeconomic panel and a daily financial panel. Our procedure performs well in capturing the data's stylized features such as time-varying volatility and fat-tails.

Identification Robust Inference for Risk Prices in Structural Stochastic Volatility Models

with Xu Cheng, Associate Professor of Economics, University of Pennsylvania
and Eric Renault, C.V. Starr Professor of Economics, Brown University

In structural stochastic volatility asset pricing models, changes in volatility affect risk premia through two channels: (1) the investor's willingness to bear high volatility in order to get high expected returns as measured by the market risk price, and (2) the investor's direct aversion to changes in future volatility as measured by the volatility risk price. Disentangling these channels is difficult and poses a subtle identification problem that invalidates standard inference. We adopt the discrete-time exponentially affine model of Han, Khrapov, and Renault (2018), which links the identification of volatility risk price to the leverage effect. In particular, we develop a minimum distance criterion that links the market risk price, the volatility risk price, and the leverage effect to the well-behaved reduced-form parameters governing the return and volatility's joint distribution. The link functions are almost flat if the leverage effect is close to zero, making estimating the volatility risk price difficult. We adapt the conditional quasi-likelihood ratio test Andrews and Mikusheva (2016) develop in a nonlinear GMM framework to a minimum distance framework. The resulting conditional quasi-likelihood ratio test is uniformly valid. We invert this test to derive robust confidence sets that provide correct coverage for the prices regardless of the leverage effect's magnitude.

Research Papers in Progress:

Jumps, Tail Risk, and the Distribution of Stock Returns

Time-varying tail risk is a fundamental underlying determinant of investors' risk and the key object of interest in financial risk management. Measuring tail risk is difficult because it requires tracking the probability of rare, extreme events. One key driver of tail risk is time-varying jump risk. I build upon my work in "Jumps, Realized Densities, and News Premia" by jointly modeling diffusion volatility, jump volatility, and returns in the S&P 500. I allow for skewness arising from both instantaneous and lagged correlations between volatility and returns. I show that the data's diffusion and jump volatilities share a common long-memory component. I then develop daily return density forecasts that perform remarkably well in practice. That is, the ensuing quantile-quantile plot is visually indistinguishable from the 45° line. The tail risk measures used by practitioners, such as Value-at-Risk and Expected Shortfall, are statistics of this density and can be easily computed.