Wu Zhu
https://zhuwu2012.github.io/
zhuwu@sas.upenn.edu

UNIVERSITY OF PENNSYLVANIA

Placement Director: Guillermo Ordonez ORDONZE@ECON.UPENN.EDU 215-898-1875
Placement Director: David Dillenberger DDILL@ECON.UPENN.EDU 215-898-1503
Graduate Student Coordinator: Gina Conway GNC@SAS.UPENN.EDU 215-898-5691

Office Contact Information
656 Ronald Perelman Center for Political Science
and Economics, 133 South 36th Street,
Philadelphia, PA 19104

Home Contact Information
#1906 3737 Chestnut St.,
Philadelphia, PA, 19104
+1 215-285-8924

Education:

Ph.D., Economics, University of Pennsylvania, 2016 – 2021
(Fields: Networks, Macro, Finance, and Machine Learning)
Thesis Title: "Networks in Macroeconomics, Finance, and Machine Learning"
Master, Statistics, Department of Statistics, Wharton, Expected in 2021
(Machine Learning)
M.A in Economics, CCER, Peking University, 2016
B.S in Materials Physics, University of Science and Technology, Beijing, 2009

THESIS COMMITTEE AND REFERENCES:

Professor Frank Schorfheide
Department of Economics, University
Of Pennsylvania, Philadelphia, PA
215-898-8486
schorf@ssc.upenn.edu

Professor Rakesh Vohra (Primary advisor)
University Professor, Department of
Economics and Electrical and Systems
Engineer, University of Pennsylvania
215-898-6777, rvohra@sas.upenn.edu

Professor Linda Zhao (Co-advisor)
Department of Statistics, Wharton,
University of Pennsylvania, Philadelphia, PA,
215-898-8228, lzhao@wharton.upenn.edu

Research Fields:

Primary Fields: Macroeconomics
Secondary Fields: Networks, Machine Learning, Asset Pricing, and Corporate Finance.

Relevant Position:

Jun2018- Sep2018 IMF (International Monetary Fund), Machine Learning, Behavior Bias and Credit Market Crashes (IMF Summer Funding Internship Program for Ph.D.)
Jan2014 - Jun2014 R.A. Counsellor Office of the State Council, Central Government, China.

Conference and Seminar Talk (* talk by coauthor):

Joint Statistical Meetings(Aug2021,American Statistical Association), American Finance Association Annual Conference (Jan2021 AFA), NBER Chinese Economy Meeting(Dec2020)*, Winter Meeting for Econometric Society(Dec 2020), NSF 6th Annual Conference for Networks Economics(x4,UChicago,Booth), Financial Management Association Annual (Nov2020,NYC), MFA(x2, Mar2020), American Economic Association Annual (Jan 2020,Sandiego), Summer Meeting Econometric Society(NA, July2019), IMF(Apr2019)*, Jane Street PhD Symposium (Jan2019), Asian Meeting of Econometric Society(Jun2019, Xiamen), Bank of Finland (Jul 2019)*, Penn-Wharton-GSM(June2019), Penn Econ(Macro Lunch, 2019), Penn Econ(Micro Theory Lunch,2019), Penn Econ(Micro Lunch,2019), PKU(June 2018), Penn Econ (Econometric Lunch,

April 2018), IMF(April 2018)*, Wharton(Oct 2017, MBA Talk), American Economic Association Annual (Jan 2016)*, Alibaba(2016), NBER-CCER Conference(June 2015)*, Stockholm-China Meeting(Sep 2014).

Teaching Experience:

Spring 2017 Economics 102, Professor Rakesh Vohra
Fall 2017 Economics 201, Professor Jose-Victor Rios-Rull
Spring 2021 Modern Data Mining, Professor Linda Zhao

Honors and Awards Related to Math:

Finalist of best Ph.D. paper (MFA,2020), Semi-Finalist of best paper in investment (Financial Management Association Annual, 2020), Wharton Mack Institute Research Fellowship (2020, Networks, Machine Learning, and Asset Pricing, with Junhui Cai, Linda Zhao), Wharton Global Impact Grant (2018,2019, under Linda Zhao), Meritorious Winner (First Prize), Mathematical Contest Modeling United States (2008), First Prize, Chinese National College Mathematical Competition of Modelling (2007), First prize, the 17th and 18th College Mathematical Olympic of China.

Programming and Skills:

Python (High Proficiency), R (Proficiency), Stata (High Proficiency), and SQL.

Research Statement:

My research spans several fields: Macroeconomics, Finance, Machine Learning, Micro Theory, and the Chinese Economy. However, it shares a common theme - the use of big data (firm-level) to emphasize the role of networks in investor behavior, business cycles, asset pricing, and systemic risk. Under this common theme, my work can be divided into three groups: *Innovation Networks, Machine Learning, and Equity-holding Networks.*

Papers under Review:

1. **The Network Effects of Agency Conflicts** (with Rakesh Vohra (Penn Econ and ESE) and Yiqing Xing (JHU), Under Review) (Winter Meeting of Econometric Society (2020Dec), NSF 6th Annual Conference in Network Economics (U Chicago Booth))
2. **Tiered Intermediation in Business Groups and Targeted SME Support** (with Yu Shi (IMF) and Robert M Townsend (MIT), Under Review) (Finalist of best Ph.D. paper (MFA, 2020), AEA 2020, IMF 2020, NSF 6th Annual Conference in Network Economics(UChicago,Booth,2020), Asian Econometric Meeting 2019, North American Econometric Meeting 2019, Penn, Wharton, IMF, PKU, CUFE, VOX China)

Papers on Innovation Networks:

3. **Networks and Business Cycles.**
(Job Market Paper, with Yucheng Yang) (Talk: UPenn, Princeton)
The speed at which the US economy has recovered from recessions ranges from months to years. We propose a model incorporating innovation network, production network, and cross-sectional shock and show that their interactions jointly explain the large variations in the recovery speed across recessions in the US.
Besides the production linkages, firms learn insights on production from each other through the innovation network. Using the eigenvalue decomposition, we show that the shock's sectoral distribution plays a crucial role in its amplification and persistence when the innovation network takes a low-rank structure.
We estimate a state-space model of the cross-sectional technology shock and document a set of new stylized facts on the structure of the innovation network and sectoral distribution of the shock for the US. We show that the specific low-rank network structure and the time-varying sectoral distribution of the shock can well explain the large variation in the recovery speed across recessions in the US. Finally, to emphasize the prevalence of the channel, we explore the application of the theory in asset pricing.

4. **Innovation Networks, Linking Complexity, and Cross Predictability**
(FMA(Oct, 2020))
This paper provides evidence that network complexity limits investors' ability to process non-local information, through the lens of return cross predictability. Using firm-to-firm citation networks, we find that the non-local indirectly linked firms can well predict the return of the focal firm, while the predictability of the local directly linked firms is weak. A long-short strategy using the indirect links yields a risk-adjusted monthly alpha of 198 (164) basis points with equal (value) weights. We further find that (i) the indirect citation links are much more complex than direct ones, (ii) the magnitude of cross predictability increases with the degree of link complexity, (iii) institutional investors don't adjust their positions in a stock with complex links, but in one with simple links immediately, (iv) firms with more complex links receive more public attention, are much larger in size, and exhibit less idiosyncratic volatility than those with simple links.
5. **Networks, Long-Run Risk, and Asset Pricing** (come out soon, draft available)
This paper proposes a networked economy incorporating innovation network, production network, and cross-sectional technology shock with E-Z preference. We, theoretically and empirically, argue that the low-rank structure of the innovation network and the sectoral distribution of the technology shock provide a channel to yield a small but persistent component in the expected consumption growth – the long run risk in the consumption growth. This endogenized persistent component yields a very large time-varying variation in the stochastic discount factor and can well explain several puzzles of the financial market – equity premium puzzle, the risk-free rate, and the market return volatility. Besides the explanation of the theory on the puzzles at the aggregate level, we further explore the cross-sectional asset pricing implications of the networked economy.

Papers on Machine Learning:

6. **Semi-supervised Learning in Networks** (with Junhui Cai (Wharton Stats), Dan Yang (HKU), Linda Zhao (Wharton Stats)) (JSM 2021, American Statistical Association)
7. **Identifying Underlying Links and Cross Predictability.** (with Junhui Cai (Wharton Stats), Linda Zhao (Wharton Stats), in progress)
8. **Deep Learning in Dynamic Networks and Foresting** (with Junhui Cai, and Linda Zhao)
In reality, firms are usually linked through various relationship – customer-suppliers, geographical overlapping, technology flow, equity-holding, business overlapping etc. There are two things worth mentioning. First, the links usually dynamically change. Second, the links are usually partially observable either due to the high collection cost or sizable measurement errors. In this paper, we model the latent networks as state variable which evolves over time, each period the state variables will be updated based on its value of the last periods, the latest partially observable counterparts, and the stock returns. We incorporate this process into a Recursive Neural Network with super high dimension of state variables, and significant boost the cross-predictability.

Papers on Equity-holding Networks:

9. **Ownership Networks and Firm Growth – What do 5 Million Firms Tell us about Chinese Economy?** (with Allen Franklin, Junhui Cai, Xian Gu, Jun "QJ" Qian, Linda Zhao) (AFA 2021, NBER China Workshop 2020, 6th Annual Network Conference 2020, MFA 2020, FMA 2020, 2nd Annual USYD Financing and Banking Research (Sydney,2019), Bank of Finland 2019)
10. **State-Owned Enterprises in China Revised** (with Junhui Cai, Xian Gu, and Linda Zhao, come out soon, draft available)

Quantitative Courses Taken (all PhD Level):

Deep Learning in Theory, Optimization in Machine Learning, Non-Parametric & Machining Learning, Data Mining, Econometrics I, Bayesian Econometrics II, Econometrics IV, Continuous Time Asset Pricing, Asset Pricing, Empirical Methodology of Asset Pricing, Empirical Corporate Finance, Probability Theory, Stochastic Process I, Stochastic Process II, Measure Theory, Real Analysis, Financial Market and Macro Finance.