Chenyu (Sophia) Mao
5711 Tennyson St
Riverdale, MD 20737
maocy@econ.umd.edu
(240) 413-0620

December 9, 2019

To the selection committee,

Attached please find my CV and application essay for the NBER behavioral macroeconomics research boot camp. I am a second-year PhD student at the University of Maryland, majoring in macroeconomics with interest in behavioral economics.

The goal of my research is to study how the behavioral biases of investors affect the aggregate economy through fluctuations in asset prices. The boot camp will provide me a valuable opportunity to learn from the leading researchers in this field, such as Professor Andrei Shleifer and Professor Ulrike Malmendier.

Professor John Haltiwanger will write a recommendation letter for me. I am happy to provide any further information if needed. Thank you very much for considering my application for the NBER behavioral macroeconomics research boot camp.

Sincerely yours,

Chenyu Mao

CHENYU (SOPHIA) MAO

5711 Tennyson St
Riverdale, MD 20737

Phone: (240) 413-0620
Email: maocy@econ.umd.edu

EDUCATION

Ph.D. Economics, University of Maryland at College Park, Aug 2018 - present
M.Sc. Economics and Finance, CEMFI, Spain, Sep 2016 - Jun 2018
B.Sc. Statistics, University of Hong Kong, China, Sep 2012 - Jun 2016
Exchange student, University of Toronto, Canada, Jan 2014 - Apr 2014

FIELDS OF SPECIALIZATION

Primary: Macroeconomics, Finance
Secondary: International Finance

RESEARCH PAPERS

"Housing, portfolio choice and wealth inequality in Spain," Master degree thesis, supervised by Prof. Samuel Bentolila, CEMFI

This paper studies the effect of housing price fluctuations on wealth inequality through a portfolio effect and a price effect. I follow the methodology proposed by Chetty et al. (2017) to estimate the effect of housing on portfolio choice by distinguishing the effect of mortgage debt and home equity and by endogenizing these two variables. The empirical results suggest a negative correlation between housing price and the share of risky assets in the household portfolio. Then I study the direct effect of asset price fluctuations on the overall wealth inequality using Gini decomposition. Combining these two effects, this paper shows that an increase in housing price mitigates the overall wealth inequality directly through price effect and indirectly through reducing the risky share in the household portfolio.

"Uncovering the relationship between the Black Death and the 'Little Divergence' across Europe," Undergraduate dissertation, supervised by Prof. Chenggang Xu, University of Hong Kong

Recent literature points out that the origin of the "Little Divergence" may trace back to the late Middle Ages, after the outbreak of the Black Death but the mechanism is still unclear. This paper constructs a theoretical map on the causal relationships and provides some empirical evidence based on a novel city-level dataset on the mortality rate estimates of the Black Death. The results suggest that the Black Death did not impact the urban development directly but took an effect through institutions channel, that is, the higher mortality rate lead to a higher probability of developing a favorable institution for urban economic growth.

"Kelly criterion and its applications on multivariate portfolio optimization," Undergraduate paper, supervised by Prof. Guosheng Yin, The University of Hong Kong

Kelly criterion is an asset allocation principle that maximizes the expected geometric growth rate of the terminal wealth. Theoretically, it outperforms all the other strategies in the long run but in practice, its short-term behavior is quite risky. In this paper, I apply the Kelly criterion to multivariate portfolio optimization problems in the horse racing market and the stock market. By evaluating the performance under different scenarios and strategies, I provide some insights of the Kelly criterion's performance in real situations.

TEACHING EXPERIENCE

Instructor, Applied Econometrics (undergraduate), University of Maryland, Fall 2019
Teaching Assistant, Intermediate Macroeconomic Analysis (undergraduate), University of Maryland, Fall 2018 and Spring 2019

RESEARCH AND RELEVANT WORK EXPERIENCE

Research Assistant, Prof. Nezih Guner, CEMFI, Summer 2017

- Constructed a micro-level panel dataset of demographic, labor and income data for 35 developing countries using household survey data
- Analyzed the cross-country heterogeneity and demographic pattern of poverty and inequality measures based on the panel dataset

Seasonal Analyst, Macro Research team, Global Investment Research Division, Goldman Sachs, Hong Kong, August 2014 - August 2015

- Collected economic and financial data of Asia economies and conducted econometric analysis
- Assisted in drafting regular publications (e.g. economic data comments) and presentations

Research Assistant (part-time), Division of Landscape Architecture, University of Hong Kong, Summer 2014

- Applied logistic and probit regression models to analyze transplanting tree survival data

GRANTS AND AWARDS

Master Student Scholarship, CEMFI, 2017
Dean's Honours List, Faculty of Science, The University of Hong Kong, 2013, 2016
C.V. Starr Scholarships, The University of Hong Kong, 2014
Summer Research Fellowship, Faculty of Science, The University of Hong Kong, 2014

Ph.D. COURSES

Econ 601 Macroeconomic Analysis I	Prof. Shea and Drazen (A)
Econ 603 Microeconomic Analysis I	Prof. Filiz-Ozbay and Ausubel (A)
Econ 623 Econometrics I	Prof. Chao (A+)
Econ 602 Macroeconomic Analysis II	Prof. Aruoba and Haltiwanger (A+)
Econ 604 Microeconomic Analysis I	Prof. Ozbay and Vincent (A-)
Econ 624 Econometrics II	Prof. Kuersteiner and Prucha (A+)
ME421(LSE) Tools for Macroeconomists: The Essentials	Prof. den Hann and Sedlacek (P)
ME422(LSE) Tools for Macroeconomists: Advanced Tools	Prof. den Hann and Rendahl (P)
Econ 701 Advanced Macroeconomics I	Prof. Haltiwanger (current)
Econ 747 The Macroeconomics of Imperfect Capital Markets	Prof. Drechsel (current)
Econ 742 Advanced International Economics II	Prof. Nuno (current)

TECHNICAL SKILLS

Stata, SAS, R, Eviews, Matlab, Fortran, Bloomberg, Haver Analytics, Thomson Reuters

LANGUAGES

Mandarin Chinese (native), English (fluent), Spanish (beginner)

REFERENCES

Prof. John Haltiwanger	University of Maryland	haltiwan@econ.umd.edu	(301) 405-3504
Prof. Luminita Stevens	University of Maryland	stevens@econ.umd.edu	(301) 405-3515

Behavioral Macroeconomics Research Boot Camp Essay

Chenyu (Sophia) Mao
The University of Maryland

December 9, 2019

My Research Question and Motivation

In his Nobel Prize lecture, "Behavioral Macroeconomics and Macroeconomic Behavior," George Akerlof (2001) urged researchers to move beyond neoclassical models with full rationality to models with realistic assumptions, grounded in psychological and sociological observations. A few years later, the Great Financial Crisis hit the economy by surprise and raised the need for a richer framework to explain boom-bust cycles, particularly in the area of modeling credit cycles and asset prices.

The goal of my research is to study how the behavioral biases of investors affect the aggregate economy through fluctuations in asset prices. There is substantial empirical and experimental evidence that individuals are not fully rational in forecasting future asset prices. For example, overconfidence is observed among professional traders and investment bankers (Glaser et al. (2013)). Another important observation is that investors have extrapolative beliefs: their estimate of future asset prices is biased by the value of recent asset prices. Experiments such as Haruvy et al. (2007) find direct evidence of it. Moreover, investors are observed to have heterogeneous expectations and the degree of heterogeneity evolves over time (Branch and McGough (2018)). A growing literature has investigated the implications of different assumptions of expectation formation on asset prices. To name a few, researchers find that models of overconfidence can plausibly capture asset price patterns such as high trading volume and excess volatility that are difficult to reconcile with rational expectation models, see, e.g. Daniel and Hirshleifer (2015), Scheinkman and Xiong (2003). And models with extrapolative expectations can explain the formation of asset bubbles, see, e.g., Adam et al. (2017), Barberis et al. (2018). Moreover, incorporating the heterogenous expectations into behavioral finance models allows researchers to further explain the cross-sectional patterns of asset holdings and investors' heterogeneous responses to the recent financial crisis (Malmendier et al. (2019)).

These pieces of evidence have been documented and studied extensively in the behavioral finance literature but have not been incorporated into the standard macro-finance model (Kiyotaki and Moore (1997); Bernanke et al. (1999)). In the standard macro-finance models, the expectation of asset prices is the key to generate amplification in the macroeconomy, which is assumed to be rational. Despite their success in explaining the amplification in business cycles, it is difficult to use the macro-finance models to generate business cycles of a magnitude comparable to what we observe in the data. Therefore, I would like to extend the macro-finance models with more realistic behavioral assumptions and explore their usefulness in explaining the magnitude and source of business cycles.

Kiyotaki-Moore model under adaptive learning

In my preliminary study, I incorporate a reduced-form adaptive learning rule in the Kiyotaki-Moore (1997) model to analyze the effect of adaptive expectations on the business cycle fluctuations. It is inspired by Bordalo et al. (2018) who develop a neoclassical macroeconomic model with diagnostic expectations to capture the excessively volatile credit cycles. Relative to Bordalo et al. (2018), I simplify the expectations formation process and include financial frictions in the form of collateral constraint.

The agents have adaptive expectations on the future asset price, taking the form $q^e_{t+1} = \lambda q_{t+1} + (1-\lambda)q^e_t$, where q^e_{t+1} is borrowers' subjective valuation of the asset price at time t+1. It is a weighted average of future asset price forecast under rational expectation q_{t+1} and the bounded-rational valuation of the asset price in the current period q^e_t.

The modified equilibrium conditions [1] are as follows:

$$q_t - \frac{1}{R}q^e_{t+1} = \frac{1}{R}G'[\frac{1}{m}(\bar{K} - K_t)]$$
$$K_t = \frac{1}{q_t - \frac{1}{R}q^e_{t+1}}[(a_t + q_t)K_{t-1} - RB_{t-1}]$$
$$B_t = \frac{1}{R}q^e_{t+1}K_t$$
$$q^e_{t+1} = \lambda q_{t+1} + (1-\lambda)q^e_t$$

To illustrate the effect of the adaptive expectations, I solve a numerical example with parameters consistent with assumptions in the KM model. Figure 1 demonstrates the impulse response functions of asset price Q, expected asset price in the next period Qe, bond holding B and capital holding K following a one-period productivity shock on a. When $\lambda = 1$, all agents are rational and the impulse response functions in figure 1a are the same as the original KM model. When $\lambda = 0.7$, investors are adaptive learners who rely partially on the past information and partially on the rational expectation to forecast the future prices. The impulse response functions in figure 1b show a larger magnitude and a hump-shaped pattern. It implies that with adaptive expectations, the financial frictions create even larger amplification in the aggregate economy and match the hump-shaped pattern we observe in some aggregate macroeconomic data such as consumption. With a λ low enough, the impulse response functions begin to oscillate, indicating that if there are too many irrational investors in the market, we may end up with multiple equilibria and bubbly outcome. This result is similar to the findings in the "limits to arbitrage" literature in behavioral finance (e.g. Shleifer and Vishny (1997)), which argues that it can be difficult for rational traders to undo the dislocations caused by less rational traders.

The result in the preliminary study has shown the potential of incorporating behavioral biases in the macro-finance model to account for richer business cycle dynamics. In the future, I would like to develop models with more sophisticated expectations of future asset prices and endogenize the choice of expectation rules. Furthermore, it is interesting to consider the role of heterogeneous expectations in generating a heterogeneous response to the business cycle shocks.

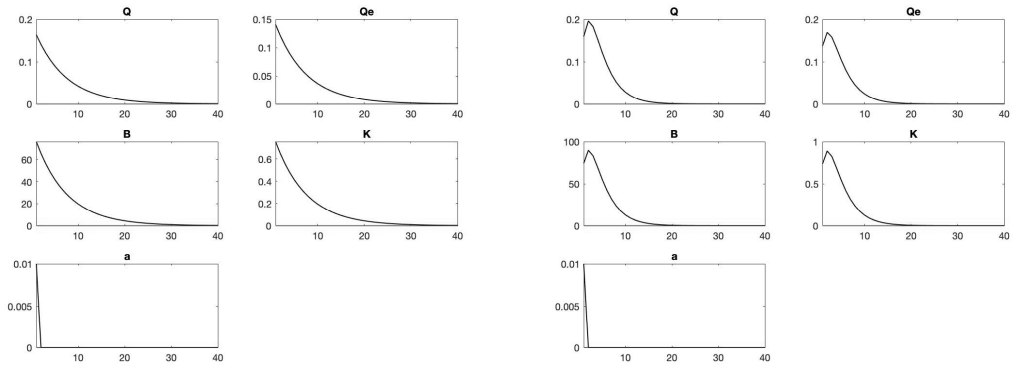
NBER Behavioral Macroeconomics Research Bootcamp

Participating in the research boot camp will provide me a great opportunity to learn about the frontier research topics in the behavioral macroeconomics field. I am particularly interested in the work of Professor Andrei Shleifer and Professor Ulrike Malmendier on behavioral credit cycles and behavioral asset pricing, which offer me valuable insights. In addition, I am eager to know more about other research topics in the behavioral macroeconomics field from both active researchers and fellow participants. The opportunity to explore ideas and discuss with others in this workshop will be an excellent head start for my future research.

As a second-year PhD student at the University of Maryland, I have received systematic training in Microeconomics and Macroeconomics, allowing me to understand the models and techniques used extensively in the behavioral macroeconomics field. In my second year courses, I started to initiate research questions and build up my own model to answer them. For instance, in Professor Haltiwanger's advanced macroeconomics course, I incorporated financial frictions in the standard open economy heterogeneous firm model to analyze whether trade liberalization could indeed reduce misallocation in the presence of financial frictions. This research experience helps my transition from the consumption of research to the production of it. Next semester, I will take a micro behavioral economics course to explore the frontier findings in this area and lay a solid micro-foundation for my research agenda. These experiences allow me to make the most of the workshop and also, bring my own insights to the topics to be discussed. I am looking forward to being part of the NBER behavioral macroeconomics research boot camp.

[1] The equilibrium conditions are based on the simple model in section 2 of Kiyotaki and Moore (1997) where asset supply is fixed and therefore, the asset price is solely determined by the demand side.

Appendix



(a) $\lambda = 1$ (b) $\lambda = 0.7$

Figure 1: Impulse response functions of the KM model with adaptive learning

References

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Barberis, N., Greenwood, R., Jin, L., and Shleifer, A. (2018). Extrapolation and bubbles. *Journal of Financial Economics*, 129(2):203–227.

Bernanke, B. S., Gertler, M., and Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of macroeconomics*, 1:1341–1393.

Bordalo, P., Gennaioli, N., and Shleifer, A. (2018). Diagnostic expectations and credit cycles. *The Journal of Finance*, 73(1):199–227.

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Daniel, K. and Hirshleifer, D. (2015). Overconfident investors, predictable returns, and excessive trading. *Journal of Economic Perspectives*, 29(4):61–88.

Glaser, M., Langer, T., and Weber, M. (2013). True overconfidence in interval estimates: Evidence based on a new measure of miscalibration. *Journal of Behavioral Decision Making*, 26(5):405–417.

Haruvy, E., Lahav, Y., and Noussair, C. N. (2007). Traders' expectations in asset markets: experimental evidence. *American Economic Review*, 97(5):1901–1920.

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Malmendier, U., Pouzo, D., and Vanasco, V. (2019). Investor experiences and financial market dynamics. *Journal of Financial Economics*.

Scheinkman, J. A. and Xiong, W. (2003). Overconfidence and speculative bubbles. *Journal of political Economy*, 111(6):1183–1220.

Shleifer, A. and Vishny, R. W. (1997). The limits of arbitrage. *The Journal of finance*, 52(1):35–55.

UNIVERSITY OF MARYLAND
Department of Economics

3114 Tydings Hall
College Park, Maryland 20742-7211
301.405.3266 TEL 301.405.3542 FAX

December 9, 2019

Letter of Recommendation for Sophia Chenyu Mao:

I am happy to write a letter on behalf of Sophia Mao who is a candidate for the NBER Bootcamp on Behavioral Economics. Sophia is a second-year student in our current program. I have had her as a student in my graduate classes including this Fall and she did (and is doing) quite well.

In my observation on all of these activities, I think Sophia is an excellent student who shows great promise as a professional economist. I think she has the potential to conduct high quality dissertation research and attending this bootcamp would help greatly in making this happen.

Her research interests fit well with the planned behavior bootcamp. She is especially interested in financial frictions and how extending macro-finance models to include more realistic behavioral assumptions may help us understand business cycle fluctuations. She has developed an interesting proposal using a Kiyotaki-Moore model under adaptive learning. She is interested in the interaction of rational and less rational (rule of thumb) investors in this environment. While her research plans are still at a fairly early stage, this proposal highlights her skills and also highlights her broader interest in behavioral issues.

Of the students I am recommending for this bootcamp, Sophia likely has the best theoretical skills. She has also been chatting about her ideas with my colleague Lumi Stevens who has written to me (who has similar views):

I have spoken with Sophia a few times about her research ideas, and based on these discussions I strongly recommend her for this workshop. Her broad research goal is to build a tractable framework that relaxes the full-information rational expectations (FIRE) assumption that dominates current dynamic macro-finance models. Sophia starts from the basic observation that in these models, agents' expectations of future asset prices are a central piece of the financial amplification mechanism. She proposes relaxing the FIRE assumption to explore the dynamics of the aggregate economy under expectations formation processes that are more consistent with survey and experimental data. This is a rich research area, with high potential rewards. Relaxing the FIRE assumption may not only lead to significantly different dynamics but also have important normative implications for policies aimed at responding to financial crises. In our discussions, Sophia has shown strong theoretical skills, so I believe that she would be able to integrate well into her work ideas from different areas/disciplines. At Maryland, Sophia would be able to draw on both our macro-finance faculty and our behavioral-information frictions faculty in both micro and macro, so she would be in a good position to work at the intersection of these two large areas.

In short, Sophia is an excellent student who would benefit tremendously from the opportunity to learn from the teachers at the Bootcamp along and her fellow students. I urge you to support her application.

Sincerely,

John C. Haltiwanger

John C Haltiwanger
Distinguished University Professor