Application for Behavioral Macroeconomics Research Boot Camp

Tolga Ozden

November 28, 2019

This application package includes: (i) contact information of the applicant and the name of the recommendation letter writer, (ii) an essay explaining the rationale for attending the boot camp, (iii) a list of all courses taken during the M.Phil and a CV.

Contact information

Applicant name: Tolga Ozden
Affiliation: University of Amsterdam
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Recommendation letter writer: Prof. Cars Hommes
(E-mail: c.h.hommes@uva.nl)

Rationale for attending the boot camp

I am a PhD student at the department of econometrics, University of Amsterdam. Under the supervision of Cars Hommes (CeNDEF, University of Amsterdam) and Kostas Mavromatis (Dutch Central Bank), my dissertation deals with the estimation of DSGE models under adaptive learning, as well as monetary, fiscal and macroprudential policy analysis in this class of models.

I am currently on the third year of my PhD and have worked on a number of topics in adaptive learning in collaboration with several central banks. My first two papers (joint projects with my supervisors) are concerned with a class of misspecification equilibria that we call *Behavioral Learning Equilibria* (BLE), which start from the premise that agents use a simple, univariate AR(1) forecasting rule in forming their expectations about future economic variables. In the first paper, I introduce algorithms to find and estimate such equilibria,

and apply them to the baseline New Keynesian model as a proof of concept to show how parameter estimates will differ from a Rational Expectations equilibrium (REE), and how multiple stable equilibria may arise in regions associated with a unique REE. In the second paper, I refine the estimation algorithm and apply it to Smets-Wouters (2007) model. I show how a BLE may help improve the model fit and out of sample forecasting performance in this more realistic setup. I further show how the notion of BLE may help with some well-known issues in the estimation and simulation of adaptive learning models with small forecasting rules, such as the initialization of learning algorithms and the use of projection facilities.

My third paper (joint project with Rafael Wouters, funded by the National Bank of Belgium) deals with the estimation of Markov-switching DSGE models under adaptive learning. This paper considers an environment where some parameters, such as the inflation reaction of monetary policy, are subject to regime switches, which are not directly observed or immediately trusted by economic agents. Instead, agents infer about the economic environment every period as new observations become available. I provide a general framework and a toolkit to estimate such models, and consider the zero lower bound period for the U.S. economy as a benchmark application in a two regime framework. I show how the adaptive learning framework may overcome several shortcomings typically found in regime-switching REE models, such as excessively large fiscal multipliers over the zero lower bound period.

I am currently collaborating with the Financial Stability Division at the Bank of England in developing a standard benchmark REE model, and a behavioral version of the model for evaluating macroprudential policy and housing tools.

My main research agenda is to operationalize behavioral macro models and introduce them into central banks' benchmark policy toolkits. In particular, I would like to see behavioral DSGE models being used at the same intensity as Rational Expectations DSGE models for policy evaluation during my lifetime. To this end, I do not only focus on developing new behavioral models and approaches, but also on making them accessible to policymakers' that may not be familiar with the technical details of such models through ready-to-run toolkits and user interfaces.

Given this goal, my rationale for attending the boot camp is threefold: first, I think this is great opportunity to get up to speed with several strands of recent literature in behavioral macroeconomics, in particular the Rational & Behavioral Inattention literature, and the use of survey data on inferring about macroeconomic expectations. The boot camp provides an ideal place to do that. Second, I would like to explore, for current potential future projects, whether and to what extent I can use these approaches in combination with adaptive learning applications, e.g. a Behavioral Inattention model with adaptively learning agents. Third and most importantly, I think the boot camp provides a great opportunity to meet the leading scholars in the field, as well as other PhD students working on similar topics.

tinbergen institute

Diploma Master of Philosophy in Economics / Statement of the Curriculum
Major: Econometrics and Operations Research

Tolga Özden

born on July 14, 1992 in Fatih, Turkey

Code	Program	ECTS	Result*
	Core courses		
TI010	Mathematics I	4	9
TI082	Mathematics II	4	7.5
TI012	Statistics	4	9
TI013	Econometrics I	4	9
TI014	Econometrics II	4	10
TI007	Macroeconomics I (Dynamic Stochastic General Equilibrium Models)	4	7.5
TI098	Macroeconomics IV (Financial Frictions in Macroeconomics)	4	6
TI099	Asset Pricing	4	8
TI100	Corporate Finance Theory	4	7
TI140	Microeconomics I (Individual Decision Making and General Equilibrium)	4	9
TI002	Microeconomics II (Game Theory)	4	7.5
TI141	Microeconomics III (Information and Contract Theory)	4	8.5
TI142	Microeconomics IV (Behavioral Economics)	4	8.5
TI143	Principles of Programming in Econometrics	1	VD
TI145	MPhil Seminar Series and Academic Writing	1	VD
	Field Courses		
TI152	Advanced Microeconometrics	3	8.5
TI022	Advanced Time Series Econometrics	3	7.5
TI147	Bayesian Econometrics	3	7
TI119	Behavioral Finance	3	9
TI126	Behavioral Macroeconomics	3	8
TI127	Complexity and Behavior	3	9
TI128	Economics of Networks	3	8.5
TI161	Empirical Asset Pricing	3	7.5
TI163	History of Economic Thought	3	8
TI078	Institutions and Financial Structure	3	7
TI144	Measure Theory and Stochastic Processes	3	8.5
TI167	Statistical Learning and Data Science (TI Econometrics Lectures 2017)	3	9
Thesis	Bayesian Estimation under Misspecification: A Behavioral Learning Equilibrium in Linearized DSGE Models	30	8.5

*Dutch grading system on a scale from 1 to 10

Amsterdam
August 29, 2017

Professor P.A. Gautier
On behalf of the Examination Board TI

Graduate school and Institute for economic research of Erasmus University Rotterdam,
University of Amsterdam and VU University Amsterdam.

Tolga Ozden

PhD Candidate in Economics

14 July 1992

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Programming

Matlab (Daily)

C & C++

oxMetrics

Stata

R

NetLogo

Julia

Eviews

Languages

Turkish (Native)

English

German

Japanese

Dutch

*Evaluations are partially available upon request.
**The latest available drafts can be found on my personal webpage.
***Invited with additional travel grant.

Hobbies

Fields of Research

Time Series Analysis, Adaptive Learning, Bayesian Econometrics, Monetary Economics.

Education

10.2017–	PhD Candidate in Economics Department of Quantitative Economics Supervisor: Prof. Cars Hommes (*University of Amsterdam*)	University of Amsterdam
2015-2017	M.Phil in Economics (8.3/10, *highest distinction*)	Tinbergen Institute
2012-2012	Erasmus Exchange Program Department of Economics	Utrecht University
2011-2015	B.A in Economics (3.9/4, *highest distinction*)	Bogazici University
2006-2011	German Abitur High School	Istanbuler Gymnasium

Research Visits & Relevant Work

2019	PhD Intern, Prudential Policy Directorate Bank of England, London
2018	PhD Intern & Visiting Scholar, Research Department National Bank of Belgium, Brussels
2018	Simulation-Based Science Weekly Meetings, Coordinator Institute for Advanced Studies, University of Amsterdam
2015	Research Assistant, Center for Econometrics Bogazici University
2014	Summer Intern, Deutsche Bank, Istanbul

Awards & Achievements

2015-2017	Amsterdam Merit Scholarship, *University of Amsterdam*
2015-2017	Full Scholarship, *Tinbergen Institute*
2015	Holland Scholarship, *University of Amsterdam*
2015	2^{nd}/120, Department of Economics , *Bogazici University*
2012	Erasmus Mobility Grant, *Bogazici University*
2011-2015	Ibrahim Bodur Scholarship, *Kale Holding A.S*, Turkey

Teaching Portfolio*

2017-2020	Teaching Assistant Time Series Econometrics (Bachelor, 3^{rd} year) Mathematical Economics (Bachelor, 3^{rd} year)	University of Amsterdam
2016-2017	Teaching Assistant Time Series Econometrics (M.Phil, 1^{st} year) General Equilibrium Theory (M.Phil, 1^{st} year)	Tinbergen Institute
2016-2017	Teaching Assistant Introduction to Finance (Bachelor, 1^{st} year)	Amsterdam Business School
2016-2017	Teaching Assistant Various MSc Finance/MBA courses	Amsterdam Business School
2013-2015	Teaching Assistant Public Finance (Bachelor, 3^{rd} year) Industrial Organization (Bachelor, 3^{rd} year) Intermediate Microeconomics (Bachelor, 2^{nd} year)	Bogazici University

Selected Presentations

2019 *-Expectations in Dynamic Macroeconomic Models (poster), Barcelona GSE Summer Forum.*

-Bank of England Internal Seminar, London

-WEHIA 2019, Bank of England Invited Policy Sesssion, City University London.

-Economic Modeling and Data Science (EcoMod 2019), University of the Azores, Ponta Delgado.

*-Doctoral Summer Workshop in Economics (Scientific Committee & Discussant), Venice***.*

-Doctoral Workshop (QED Network), Nova Business School, Lisbon.

2018 *-14th Dynare Conference, European Central Bank, Frankurt.*

*-New Ways of Thinking about Economic Policy (Discussant), Bank of England, London***.*

-Computing in Economics and Finance (CEF 2018), Milan.

*-New Approaches to Macro-Financial Instability, Bamberg***.*

-Workshop on Adaptive Learning in Macroeconomics, Bilbao.

-SBS Weekly Meetings, Institute for Advanced Studies, University of Amsterdam.

-CIMS DSGE Summer School Conference, University of Surrey.

*-Doctoral Workshop on Economic Theory, Bielefeld***.*

External Courses, Workshops and PhD Training

-Empirical Time Series Methods for Macroeconomic Analysis, Barcelona GSE Summer School, 2018

-Advanced Course on Occasionally Binding Constraints, University of Surrey, 2018

-Macroeconomic Modeling of Regime Switches, CEF 2018 Pre-Conference Workshop, 2018

-Statistical Learning and Data Science, Tinbergen Econometrics Lectures, 2017

-Expectations in Dynamic Macroeconomic Models, Dutch Central Bank, 2016

References

Research

Cars Hommes
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University of Amsterdam, Department of Economics
Senior Research Advisor, Bank of Canada
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Rafael Wouters
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National Bank of Belgium
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Kostas Mavromatis
Economist
De Nederlansche Bank
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Edward Castronova
Professor of Media
Indiana University Bloomington
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Teaching

Cees Diks
Department of Economics, University of Amsterdam
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Jan Tuinstra
Department of Economic, University of Amsterdams
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Research

Restricted Perceptions and Regime Switches[**]
(Joint with Rafael Wouters)

***Abstract**: We consider the estimation of Markov-switching DSGE models under adaptive learning (AL) in order to study the interaction between expectations and the business cycle over the Zero Lower Bound period. We assume that regime shifts by monetary policy are not directly observed by agents, instead they indirectly infer about the regimes to the extent that it feeds back into their information set. This setup results in so-called Restricted Perceptions Equilibria (RPE) consistent with a given information set, and standard E-stability conditions are applicable to these equilibria. We illustrate these conditions in two environments: a basic Fisherian setup, and the benchmark 3-equation New Keynesian model. We then use a variant of the Kim & Nelson (1999) filter to estimate MS-DSGE models under constant gain adaptive learning. Based on estimations of the 3-equation NKPC and workhorse Smets-Wouters models, our results can be summarized as follows: adaptive learning models outperform the REE benchmark in all cases and the Regime-switching REE model in most cases, suggesting that Markov-switching and Adaptive Learning approaches can be complementary in terms of model fit. Furthermore, we observe that the impulse responses and shock propagation differ under AL and REE setups: both supply and demand shocks can be subject to different patterns under AL over the transition period to the ZLB episode, depending on the information set. Focusing particularly on government spending shocks, we find that the proportional change in fiscal multipliers over the ZLB period is smaller under AL compared to the REE benchmark. This suggests that standard models may severely overestimate the impact of a fiscal expansion over this period following the 2007-08 financial crisis.*

**Behavioral Learning Equilibria in the New Keynesian Model,
De Nederlansche Bank Working Papers No. 654**
(Joint with C. Hommes, K. Mavromatis and Mei Zhu)

***Abstract**: We introduce the concept of behavioral learning equilibrium (BLE) into a high dimensional linear framework and apply it to the standard New Keynesian model. For each endogenous variable, boundedly rational agents use a simple, but optimal AR(1) forecasting rule with parameters consistent with the observed sample mean and autocorrelation of past data. The main contributions of our paper are fourfold: (1) we derive existence and stability conditions of BLE in a general linear framework, (2) we provide a general method for Bayesian likelihood estimation of BLE, (3) we estimate the baseline NK model based on U.S. data and show that the relative model fit is better under BLE than REE, (4) we analyze optimal monetary policy under BLE and show that it differs from REE. In particular, we find that the transmission channel of monetary policy is stronger under BLE at the estimated parameter values.*

Sample Autocorrelation Learning in an Estimated Medium-Scale DSGE Model (In progress)
(Joint with C. Hommes & K. Mavromatis)

***Abstract**: We extend Hommes et. al. (2019) and estimate a medium-scale DSGE Model, Smets-Wouters (2007), under Behavioral Learning Equilibria (BLE) and Sample-autocorrelation (SAC) learning, where agents use a simple AR(1) forecasting rule with parameters consistent with past observed data. We compare our results to estimations under Rational Expectations Equilibrium (REE) and learning under Minimum State Variable (MSV) information set. Our contributions are as follows: (i) we show that AR(1) models, both with fixed-beliefs (BLE) and time-varying beliefs (SAC), perform better in terms of marginal likelihood and out-of-sample forecasting performance, (ii) we disentangle the effects on the information set, timing assumption and time-variation of expectations and show that the first two matter the most, (iii) we show that SAC-learning without a projection facility works as a plausible alternative to recursive least-squares learning.*

Macroprudential Policy Interactions in a Sectoral DSGE Model with Staggered Interest Rates (In progress)
(Joint with M. Hinterschweiger, K. Khairnar & T. Stratton)

***Abstract**: We develop a two-sector DSGE model with a detailed banking sector along the lines of Clerc et. al. (2015) to assess the impact of macroprudential tools (minimum, countercyclical and sectoral capital requirements, as well as and LTV limit) on key macroeconomic and financial variables. The banking sector features residential mortgages and corporate lending subject to staggered interest rates Ãă la Calvo (1983), which is motivated by the sluggish movement of lending rates due to fixed interest rate loan contracts. Other distortions in the model include limited liability, bankruptcy costs and penalty costs for deviations from regulatory capital. We estimate the model using Bayesian methods based on quarterly U.K. data over 1998Q1-2016Q4. Our contributions are threefold. We show that: (i) coordination of macroprudential tools may have a welfare-improving effect, (ii) macroprudential tools would have improved some macroeconomic indicators but not have prevented the Global Financial Crisis altogether, (iii) staggered interest rates may weaken the transmission of macroprudential tools that work through interest rates.*

Other policy papers:

Results of a massive experiment on virtual currency endowments and money demand. PLOS ONE 12(10): e0186407.
(Joint with Castronova E. and Zivic N, Andjelkovic I & Dekic M.)

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Subject: recommendation Tolga Ozden

Date December 5, 2019

To the NBER Boot Camp organizers:

I am enthusiastically writing this letter to support Tolga Ozden's application to participate in the *NBER Behavioral Macroeconomics Research Boot Camp*, March 2020 in Cambridge, MA.

Tolga Ozden is in the third year of his PhD-thesis work in the area of behavioral macro-economics and I am his main supervisor. Kostas Mavromatis, a macroeconomist from the Dutch Central Bank, is co-supervisor. To set the stage right away, Tolga is the best student of his cohort of 30 that came out of the Tinbergen Institute graduate program of the three universities UvA and Vu (Amsterdam) and Erasmus (Rotterdam). Tolga's work fits very well in the area of behavioral macroeconomics and he is one of the very best, if not the best, among the 30+ students I have supervised in the last two decades.

Tolga is working on estimation of behavioral DSGE models with adaptive learning. In particular, he is applying the *behavioral learning equilibria (BLE)* approach of Hommes and Zhu, JET 2014, to DSGE models ranging from small to medium size. The main idea here is that agents use a parsimonious univariate AR(1) forecasting rule for expectations of all endogenous variables in the economy and learn the optimal AR(1) parameters –the mean and the autocorrelation coefficient—by sample autocorrelation learning. This theory of bounded rationality is parameter free, as agents learn the optimal AR(1) forecasting heuristics from observable statistics, the mean and the autocorrelation, in an environment that is too complex to fully understand.

Tolga has a first paper *Behavioral learning equilibria in the New Keynesian model* (joint with Kostas Mavromatis, Mei Zhu and myself) that applies BLE to the standard 3 equations NK model and develops a recursive Bayesian estimation method for BLE using U.S. data. The paper shows that for general linearized DSGE models a BLE exists that is E-stable under learning. Multiple stable equilibria may coexist, with various degrees of persistence in inflation and output gap. An appealing feature of BLE is its parsimony, with two parameters that are pinned down by the most important observable statistics, the mean and the autocorrelation. A BLE matches the mean and the persistence of all endogenous variables in the model. The paper also studies optimal monetary policy, which turns out to be different from optimal policy under rational expectations. In general under BLE optimal monetary policy needs to be more aggressive and, when this is the case, the high persistence BLE is stabilized.

A second paper (still under preparation) estimates a BLE for the classical medium-size Smets-Wouters DSGE model. Tolga shows that the resulting behavioral model under learning not only provides a better fit than the rational benchmark, but also has a better out-of-sample forecasting performance. An interesting empirical phenomenon is that BLE exhibits not only excess volatility compared to rational expectations, but also *persistence amplification*, that is, the BLE

autocorrelations of inflation and output gap are much higher than the autocorrelations of the driving shocks of the economy. This persistence amplification is due to the misspecification of the simple (but plausible) AR(1) rules and leaves an important role for monetary policy to stabilize inflation and output.

Tolga has a strong interest to work at a central bank as a macroeconomist after obtaining his PhD. He strongly believes that behavioral macro models are highly relevant for more realistic policy analysis. He has already done two internships at central banks. First, a traineeship at the *Central Bank of Belgium*, where he developed close collaboration with Raf Wouters to work on the estimation of nonlinear Markov switching DSGE models under learning. This project considers an environment where some parameters, such as the inattention of the reaction to monetary policy, are subject to regime switches, which are not directly observed or immediately trusted by economic agents. Instead, agents infer about the economic environment every period as new observations become available. Tolga (joint with Raf Wouters) provides a general framework and a toolkit to estimate such models, and consider the zero lower bound period for the U.S. economy as a benchmark application in a two regime framework. The adaptive learning framework may overcome several shortcomings that are typically found in regime-switching REE models, such as excessively large scale multipliers over the zero lower bound period.

A second experience at a central bank is Tolga's internship at the *Financial Stability Division* at the *Bank of England* over the summer of 2019. The BoE has an interdisciplinary research group working on developing agent-based models (ABMs) for policy analysis. Tolga's role was to develop a standard RE benchmark medium-sized DSGE model for evaluating macroprudential policies and housing tools and to compare these with the corresponding ABM. The job market project for Tolga's PhD thesis will most likely develop a behavioral version of this DSGE model using a regime switching framework to introduce occasionally occurring financial crises. Banks and households are aware of the possibility of a crisis occurring, but do not know the objective distributions of these events and may be too optimistic or pessimistic in a given period. This setup may then be used to study optimal monetary and macroprudential policy.

In summary, Tolga has a strong interest in behavioral macro approaches for policy analysis. He would like to extend his knowledge to other behavioral modeling approaches, such as diagnostic expectations, experience weighted expectations, rational inattention, survey data analysis, etc., to see how these can be combined to improve his own behavioral models with adaptive learning.

I believe Tolga could learn tremendously from the *NBER Behavioral macroeconomics research boot camp,* which would be a highly stimulating and timely experience for him to extend his network and learn new behavioral approaches. Therefore, I strongly recommend him for the NBER boot camp.

Sincerely yours,



Cars Hommes,
Professor of Economic Dynamics
Director of CeNDEF