

# Applied Time Series Analysis and Forecasting

## ECON 684 – Course Syllabus – Spring 2024

University of Maryland, College Park

Department of Economics

Master of Science in Applied Economics Program

### Course Logistics

	Course	Instructor	Teaching Assistant
Name	ECON 684	Mark Bognanni	Chenyu Mao
Contact	<a href="https://elms.umd.edu">https://elms.umd.edu</a>	<a href="mailto:bognanni@umd.edu">bognanni@umd.edu</a>	<a href="mailto:maocy@umd.edu">maocy@umd.edu</a>
		<u>Office Hours</u>	<u>Office Hours</u>
Day	Thursdays	Tuesdays	Wednesdays
Time	6:30 PM – 9:15 PM	5:15 PM – 6:15 PM	5:00 PM – 6:00 PM
Location	<a href="#">Tydings Hall (042 TYD)</a> <a href="#">Room 2109</a>	<a href="#">Zoom</a> <sup>1</sup>	<a href="#">Zoom</a> <sup>2</sup>

### Prerequisites

The course aims to be largely self-contained, but the official prerequisites are:

- ECON 642 - Topics in Applied Macroeconomics
- ECON 645 - Empirical Analysis III: Econometric Modeling and Forecasting

I will assume students have completed those courses satisfactorily.

### Overview

This course builds on the brief introduction to time series econometrics offered in ECON 645. Students will learn the theory of stationary processes and how it applies to econometric techniques for estimation and forecasting based on time series data. The techniques will be applied in macroeconomic, financial and business applications.

More specifically, the topics covered include, among others, autoregressive-moving average processes, filters, vector autoregression models, and non-stationary time series analysis. Time permitting, we will cover other special topics in time series. We will delve into the theory of time series, but we will focus our attention on the application of these methods to data analysis. We will do so by engaging extensively in applied exercises.

<sup>1</sup><https://umd.zoom.us/j/92210380174>

<sup>2</sup><https://umd.zoom.us/j/97388028411?pwd=UlhOWnpSVG1Ba1kyZEdHWGFyNm1QUT09>

## Objectives and Learning Outcomes

The M.S. in Applied Economics program has seven general learning outcomes for students:

1. **Ability to understand, evaluate and analyze economic data.**
2. **Ability to understand and interpret statistical evidence from economic data.**
3. **Ability to apply empirical evidence to assessing economic arguments.**
4. **Ability to apply macroeconomic theories to policy discussions.**
5. Ability to apply microeconomic theories to policy discussions.
6. **Ability to communicate economic ideas to a broader audience.**
7. Ability to evaluate the effectiveness of policy programs using sound economic techniques.

The learning outcomes that pertain to this course are outcomes 1, 2, 3, 4, and 6.

## Course Website

Copies of the course syllabus, grades, and other relevant links and documents will be posted on the course's ELMS/Canvas website. You can access the site via [this link](#).<sup>3</sup> You will need to use your University of Maryland directory ID and password.

## Email

The University has adopted email as the primary means of communication outside the classroom, and I will use it to inform you of important announcements. The University creates an “@umd.edu” email address for every graduate student. All official UMD communications will be sent to students at their “@umd.edu” email address. You are responsible for reading your @umd.edu email address, including ELMS/Canvas Announcements I send to the class. You should make sure ELMS/Canvas Announcements and messages are forwarded to an email address that you check regularly. Failure to check email, errors in forwarding email, and returned email will not excuse a student from missing announcements or deadlines.

## Office Hours and Communication

The beginning of the syllabus lists office hours for me and our teaching assistant. Feel free to email me if you have questions or would like to set up an appointment outside my office hours. The times I have chosen for my office hours may not work for all of you, and I am happy to meet at other times or on other days. Please include “ECON 684” in the subject line of all emails to help me prioritize a response to you. I will not respond to emails sent from non-UMD email addresses; emails that do not include a subject, salutation, and sign-off; or emails that ask questions answered in the syllabus.

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<sup>3</sup><https://elms.umd.edu>

## Readings

Role	Reference	Abbreviation
Required - Main Text	Walter Enders, <i>Applied Econometric Time Series, Fourth Edition</i> (John Wiley & Sons, Inc, 2015).	WE
Required (free)	Francis X Diebold, <i>Elements of Forecasting</i> (Thomson South-Western College Pub., 2007).	DB
Recommended	Lutz Kilian and Helmut Lutkepohl, <i>Structural Vector Autoregressive Analysis</i> , Themes in Modern Econometrics (Cambridge University Press, 2017), <a href="https://doi.org/10.1017/9781108164818">https://doi.org/10.1017/9781108164818</a> .	KL
Recommended	James D. Hamilton, <i>Time Series Analysis</i> (Princeton University Press, 1994).	HAM

- Earlier editions of the Enders textbook are acceptable substitutes for the main text but references on the syllabus pertain to the 4th edition.
- The recommended texts are for students who want to see alternative expositions of a given topic or want to go deeper than our course requires.
- Free PDFs of drafts of the chapters of the Kilian and Lutkepohl book are available on Lutz Kilian's [website](#).
- A free PDF of the Diebold textbook is available on Frank Diebold's website [here](#).

## Class Participation and Attendance

Attendance is not explicitly part of the grade, but is strongly recommended. You are not likely to do well without regular attendance. When in class please be courteous, and avoid imposing costs to those around you; please silence your cell phones, do not browse the internet, find a seat quietly if you are late, etc. If you miss a class, it is your responsibility to obtain any missing information, notes, etc. from your classmates. If I am late to class, please wait 15 minutes before leaving.

## Coursework

### Computation, Estimation, and Simulation

**Laptop Computer Requirement:** Completing some of this course's requirements will require a laptop computer (not a notebook or a tablet!) with at least 1 GB of RAM and at least 5 GB of free space available on the hard-drive. We recommend laptops with at least a 15-inch screen. Screens smaller than 13 inches are probably not practical.

I will not dictate what computer program, programming language, or computational resources you use to perform coursework that is empirical or simulation-based. STATA would be sufficient, but if you prefer to work in R, Python, Julia, or something else then that is also fine as long as you are able to complete the assigned work.

## Grading

At the end of the term, every student will have a numerical course grade between 0 and 100. I will decide upon the numerical cutoffs between various letter grades based on my professional judgment. I will consider students' performance relative to the class. I will also consider absolute standards of professional competence. Highly competent students will get an A. Barely competent students will get a B. Incompetent students will get a B- or worse. The cutoffs that I use will respect the ordinal ranking of numerical course grades. No student with a given numerical course grade will receive a lower letter grade than someone else with a lower numerical course grade.

I will commit to the following grading scale, but I reserve the right to adjust the cutoff points downward depending on the actual distribution of scores (I may curve final grades up, I will not curve them down).

93 - 100	90 - 92	80 - 89	70 - 79	60 - 69	50 - 59	40 - 49	30 - 39	20 - 29	10 - 19	0-9
A	A-	B+	B	B-	C+	C	C-	D+	D	F

Course grades will be calculated as the weighted average of the following components.

Component	Percentage
Participation in Class Discussions	5
<a href="#">Problem Sets</a>	10
<a href="#">Exams</a>	
... Midterm Exam	20
... Final Exam	30
<a href="#">Empirical Projects</a>	
... Project 1	15
... Project 2	20
Total	100

**Re-grading:** Care is taken in grading, but there occasionally may be errors. For any disputes, you have one week (seven days) from the time the assignment or grade is returned to submit to me both the original assignment and a brief explanation of any part that you believe needs re-grading. I will regrade the entire assignment.

## Problem Sets

There will be *four* problem sets. The problem sets represent an important part of the learning experience, as well as a guide for what to expect on the midterm and final exam.

### Problem Set Submission Procedures

- Each problem set is due at 6:30 PM on its due date.
- Solutions will be provided immediately after each problem set's due date, so late submissions will not be accepted. Please plan accordingly; no extensions or makeup assignments will be given.
- *All submissions must be made electronically and exclusively via ELMS.* Students are encouraged to either type their answers, or to create a pdf document of their scanned responses (this can be done using a plethora of smartphone applications in case a scanner is unavailable). In either case, files should be submitted via ELMS before the corresponding deadline.
- *Each student must submit an individual set of answers,* though students are encouraged to collaborate and consult each other.

### Problem Set Grading

Most importantly, because the Problem Sets serve as a guide for what to expect on the exams, it is your job to ensure that you understand the posted solutions. If you cannot understand them, then you should talk to me or our TA.

The homework evaluation focuses on rewarding effort while providing some feedback on correctness. We will evaluate each homework assignment on a scale of 10 points, but we will typically assign only a few different point values, as described below.

Points Awarded	Submission characteristics
10	Correct answers and work for all or nearly all questions.
9	A mix of correct and incorrect answers.
8	Lots of incorrect answers but it's apparent that a good faith effort to complete the assignment was made.
<5	Assignment is clearly incomplete. Exact point total will depend on the degree of incompleteness.

Viewed in the context of the course's overall grading scale, you can see that the completed homework receives points corresponding to a B or better, even if most answers are incorrect.

## **Exams**

There will be two exams. Please refer to the class schedule for each exam date. All exams are closed book and will not include any computational topics. You will only need pen and paper.

- The midterm exam covers the material covered up to and including Class 7.
- The final exam will cover material from the entire course.

## **Empirical Projects**

Students will be required to work on two empirical projects. Projects will be done in small groups and mimic the style of short (i.e.: max 5 pages) policy memos, or research notes written for a professional audience. Each group will present their results from the second project in the penultimate class (see the class schedule.) Presentations should introduce and explain each group's model, as well as analyze the main drivers behind their performance and potential sources of improvements.

## **Course Schedule (tentative and subject to changes)**

I reserve the right to change the syllabus at any time throughout the semester. Some material will take longer or less time than I intended. The obvious way to stay informed about changes is to attend class.

- We will have 15 classes, two of which will be used for exams.
- Class will usually be broken into two segments of approximately 75 minutes each, with a short break between the two segments.
- Readings in parentheses, for example (HAM 5), are considered supplementary.
- It is likely that I will distribute and post additional material to the ELMS/Canvas site throughout the course.

**Class Schedule:** Note that “PS” abbreviates Problem Set and “EP” abbreviates Empirical Project.

Class Num.	Date	Topics and Events	Due	Readings
1	Jan 25	Introduction to Time Series Difference Equations (Part 1) <i>Assigned: Problem Set 1</i>		WE 1.1 WE 1.2–1.5
2	Feb 1	Difference Equations (Part 2)		WE 1.6–1.9
3	Feb 8	ARMA Models Expected Value, Variance, and Covariance (Covariance) Stationarity <i>Assigned: Problem Set 2</i>	PS 1	WE 2.1–2.6
4	Feb 15	ARMA Models (continued) Forecasting and Model Selection		WE 2.7–2.10, 2.13
5	Feb 22	Seasonality Non-stationary processes (trends, unit roots)		WE 2.11 WE 2.12, 4
6	Feb 29	Modeling Volatility Forecast distributions	PS 2	WE 3, (HAM 21)
7	Mar 7	Single Equation with Multiple Variables Graphical Presentation of Forecasts Brief Review for Midterm		WE 5.1–5.3 DB 4
8	Mar 14	<b>Midterm Exam</b>	EP 1	
	Mar 21	— No Class (University Spring Break) —		
9	Mar 28	Matrix Algebra Basics Multiple Equation Models Reduced-Form Vector Autoregression (VAR) <i>Assigned: Problem Set 3 and Empirical Project 2</i>		WE 5.4–5.6, KL 2 (HAM 10) (HAM 11.1–11.5)
10	Apr 4	Forecasting with VARs Lag Order Selection Granger Causality		KL 2.4–2.7
11	Apr 11	Simultaneous Equations Causality Structural VARs <i>Assigned: Problem Set 4</i>	PS 3	(HAM 9, 11.6) WE 5.8, KL 7 WE 5.10–5.15
12	Apr 18	Structural VARs (continued) Cointegration		WE 6
13	Apr 25	State Space Models and the Kalman Filter		(HAM 13)
14	May 2	Empirical Project 2 Presentations	PS 4 EP 2	
15	May 9	<b>Final Exam</b>		
	May 16	HOLD (in case a class gets cancelled)		

## University Policies

Policies related to all graduate courses at the University of Maryland are posted on this page of the Graduate School's website. Please familiarize yourself with these policies related academic integrity, non-discrimination policy, accessibility, absences and accommodations, grading, academic standing, grievance procedures, and other important policies.

## Workload

Mastering the material covered in this course requires a significant amount of work outside of class. Students should expect to spend more time outside of class than in class – typically at least twice as much time. In a regular 15-week semester (as in the College Park version of our program): Taking 3 master's-level courses is supposed to approach the time commitment of a full-time job (~36-39 hours per week, so 12-13 hours per week per course). Taking 3 master's-level courses while simultaneously working at a demanding full-time job during the day is not advisable. Students with questions about the workload in this program should speak with one of the program directors.

## Academic Integrity

The University of Maryland has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards applicable to all undergraduate and graduate students, and you are responsible for upholding these standards as you complete assignments and take exams in this course. Please make yourself aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information visit [this site](#).<sup>4</sup>

## Student Conduct

Students are expected to treat each other with respect. Disruptive behavior of any kind will not be tolerated. Students who are unable to show civility to one another or myself will be referred to the Office of Student Conduct. You are expected to adhere to the Code of Student Conduct.

## Academic Progress

The graduate school requires that students maintain a GPA of at least 3.0. Students whose cumulative GPA falls below 3.0 will be placed on academic probation by the graduate school. Students on academic probation must ask the program director to petition the graduate school if they want to remain in the program. The petition must include a plan for getting the student's GPA up to at least 3.0. Students who do not live up to their plan can be forced to leave the program without having earned the degree. Note: a grade of "B" corresponds to a GPA of 3.0. A grade of "B-" corresponds to a GPA of 2.7.

## Excused Absences

If you miss any class meetings for any reason, you are still responsible for all material covered during the meeting you missed. It is your responsibility to work with study partners, the teaching assistant,

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<sup>4</sup><https://studentconduct.umd.edu/you/students>



and the instructor to make sure you catch up on the missed material. Instructors routinely facilitate things by posting lecture notes, etc.

If you need to miss an exam or other graded course requirement because of illness, injury, or some other emergency: Follow doctor's orders and get documentation. Get in touch with the instructor as soon as you're able – preferably prior to missing the exam or deadline. Communicate with the instructor to make up the course requirement as soon as possible. You are entitled to recover before you make up the course requirement, but you are not entitled to extra days to study beyond the time the doctor's note says you've been incapacitated. If you are incapacitated for more than a week or so beyond the end of the term, your grade in the course will be an "Incomplete." In such cases you must negotiate a plan with your instructor for completing the course requirements. Once you make up the course requirement the instructor will change your "I" to the appropriate letter grade.

### **School Closings and Delays**

Information regarding official University closing and delays can be found on the campus website and the snow phone line: (301) 405-SNOW (405-7669). The program director will also announce cancellation information to the program as an announcement on the program's ELMS/Canvas site. This will generally be done by 1:00 p.m. on days when weather or other factors are an issue. When classes need to be canceled during the semester, we make every effort to schedule makeup classes.

### **UMD Counseling Center**

Sometimes students experience academic, personal and/or emotional distress. The UMD Counseling Center in Shoemaker Hall provides comprehensive and confidential support services that promote personal, social, and academic success. The cost of these services is covered by the fees you already paid when you registered for classes, and there is no additional charge if you use the services. Proactively explore the range of services available, including the Counseling Service, Accessibility and Disability Service, and the Testing Office, all described [here](#).<sup>5</sup>

### **Graduate Academic Counselor**

The UMD Graduate School also has an academic counselor available to support students who are having difficulty navigating mental health resources on campus, are considering a leave of absence and/or need assistance finding mental health care off campus. The Graduate Academic Counselor also facilitates bi-weekly Graduate Student Circle Sessions which provide an opportunity to learn about resources and connect with other graduate students. Students can learn more about the Graduate Academic Counselor by visiting [this site](#).<sup>6</sup>

### **UMD Accessibility & Disability Service**

The University of Maryland is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is also committed to the principle that no qualified individual with a disability shall, on the basis

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<sup>5</sup><https://counseling.umd.edu>

<sup>6</sup><https://gradschool.umd.edu/students/gradcounselor>

of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The Accessibility & Disability Service (ADS) provides reasonable accommodations to qualified individuals to provide equal access to services, programs and activities. ADS cannot assist retroactively, so it is generally best to request accommodations several weeks before the semester begins or as soon as a disability becomes known. Any student who needs accommodations should contact ADS as soon as possible so that they have sufficient time to make arrangements. For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301-314-7682, or email them at [adsfrontdesk@umd.edu](mailto:adsfrontdesk@umd.edu). Information about sharing your accommodation letter, discussing accommodation logistics and getting assistance from ADS staff and more can be found on the ADS website.

### **Student with Disabilities**

The University of Maryland does not discriminate based on differences in age, race, ethnicity, sex, religion, disability, sexual orientation, class, political affiliation, or national origin. Reasonable accommodations will be arranged for students with documented disabilities. Students who have an accommodations letter from the Accessibility and Disability Service (ADS) should meet with me during the first week of the term to discuss and plan for the implementation of your accommodations. If you require reasonable accommodations but have not yet registered with ADS, please contact the Accessibility and Disability Service at 301-314-7682 or [adsfrontdesk@umd.edu](mailto:adsfrontdesk@umd.edu).

### **Course Evaluations**

Near the end of the term, you will receive an email inviting you to submit a voluntary and anonymous course evaluation. Your feedback on courses will be very helpful in improving the quality of instruction in our program.

### **Building Access**

Morrill Hall is locked every day from 7:00 p.m. - 7:00 a.m. Your university ID gives you swipe access to the back door of the building. There is keypad access to the door of Morrill 1102. The code will be shared with students by the program coordinator.