

# USC Marshall

School of Business

## DSO 522: Applied Time Series Analysis for Forecasting

Fall 2024

Tuesdays, 6:30-9:30pm

**Instructor:** Dr. Matteo Sesia  
**Office:** [BRI](#) 401H  
**Office Hours:** Tuesdays (5:20–6:20pm)  
Additional office hours may be available by appointment, on Zoom.  
**Class Location:** [JKP](#) 212  
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### COURSE DESCRIPTION

This is a graduate-level course designed to equip students with the foundational and advanced techniques necessary for analyzing time series data and generating accurate forecasts in a variety of applications. In an era where data-driven decision-making is crucially important, the ability to forecast future trends and patterns is a highly sought-after skill across numerous industries. This course addresses the growing need for professionals who can leverage time series analysis to make informed data-driven decisions in fields such as finance, economics, supply chain management, healthcare, and environmental science. Students will learn how to effectively utilize various forecasting methods, including classical decomposition, exponential smoothing, ARIMA modeling, and more advanced techniques and modern machine learning approaches.

This course emphasizes practical application, integrating theoretical knowledge with hands-on experience through real-world datasets and state-of-the-art software tools in R packages. R is chosen for its powerful, comprehensive, and widely-used suite of tools for time series analysis, offering a rich ecosystem for data manipulation, visualization, and model implementation. Throughout the course, students will engage in projects and assignments that require them to work directly with data, building essential skills and gaining a deep understanding of time series analysis principles such as trend, seasonality, and cyclic behavior.

Students will also learn to evaluate the accuracy of forecasting models and understand the implications of forecast uncertainty. The course will cover techniques for assessing model performance and methods for quantifying and communicating forecast uncertainty. While R is the primary software used, the general skills and knowledge acquired will be easily transferable to other software platforms like Python, ensuring that students can adapt their expertise to various technological environments. By the end of the course, students will be well-equipped to apply time series analysis across various contexts, effectively contributing to their fields and driving data-informed decision-making processes.

## COURSE OBJECTIVES

Upon successful completion of this course, students will be able to:

1. **Understand Fundamental Time Series Concepts:** Develop a comprehensive understanding of time series data characteristics, including trend, seasonality, and cyclic patterns.
2. **Apply Forecasting Methods:** Learn and apply various forecasting techniques, including regression approaches, exponential smoothing, and ARIMA models, to real-world datasets.
3. **Utilize Advanced Techniques:** Know how to apply advanced forecasting methods such as non-linear regression and machine learning approaches, understanding their limitations.
4. **Gain Software Proficiency:** Achieve proficiency in using R for time series analysis and forecasting, while understanding how to transfer these skills to other software like Python.
5. **Evaluate Model Performance:** Evaluate and compare the accuracy of different forecasting models using appropriate statistical metrics.
6. **Quantify Forecast Uncertainty:** Understand and quantify forecast uncertainty, and communicate the implications of forecast errors in practical decision-making contexts.
7. **Implement Practical Applications:** Apply time series analysis techniques to various domains, demonstrating the ability to make informed, data-driven decisions.
8. **Develop Critical Thinking:** Enhance critical thinking and problem-solving skills by analyzing and addressing complex forecasting problems with appropriate methodologies.
9. **Enhance Collaboration and Communication:** Improve collaboration and communication skills through group projects and presentations.
10. **Address Ethical Considerations:** Understand and discuss the potential pitfalls of forecasting and time series data analysis, ensuring responsible applications.

## COURSE MATERIALS

The following items will be necessary for completion of reading assignments and homework.

- **Textbook.** The following textbook is available online for free at <https://otexts.com/fpp3/>. Students may purchase a printed copy, but that is not required.
- **Software.** To participate in this course, you need to install R and RStudio on your computer. Further information about the required software are provided below.
- **Additional materials.** Additional materials will be provided week by week through Brightspace.

If you have any questions or need assistance with the Brightspace Course Pages, please contact the Marshall HelpDesk at 213-740-3000 (option 2) or [HelpDesk@marshall.usc.edu](mailto:HelpDesk@marshall.usc.edu).

<b>Textbook</b>	for DSO 522, Applied Time Series Analysis for Forecasting
ISBN-13	978-0987507136
Title	Forecasting: Principles and Practice, 3 <sup>rd</sup> edition
Author	Rob J Hyndman and George Athanasopoulos
Publisher	OTexts

## **SOFTWARE – Installing R and RStudio**

First, download R from the Comprehensive R Archive Network (CRAN) at [cran.r-project.org](http://cran.r-project.org). Select the version appropriate for your operating system (Windows, macOS, or Linux) and follow the installation instructions provided.

After installing R, it is highly recommended to install RStudio, an integrated development environment (IDE) that enhances your R programming experience. Download RStudio from [rstudio.com](http://rstudio.com) and follow the installation prompts for your operating system.

Once R and RStudio are installed, open RStudio and verify the installation by running a simple command in the console, such as `print("R is successfully installed!")`. If the message appears, your setup is complete.

Additionally, you will need to install the R package “fpp3” along with its dependencies. Open RStudio and run the following commands to install this package: `install.packages("fpp3")`.

With these installations complete, you will be ready to start working on the course materials. If you encounter any issues, please reach out for assistance.

## **SOFTWARE – Setting Up RMarkdown**

To set up RMarkdown in RStudio, open RStudio and install the RMarkdown package by running the following command in the console: `install.packages("rmarkdown")`. After installation, you can create a new RMarkdown document by going to File > New File > R Markdown. Follow the prompts to set up your document. You can render the RMarkdown document by clicking the "Knit" button, which will generate a formatted document (HTML, PDF, or Word) that includes both your code and its output.

To compile markdown documents into PDF format, you will need to also have a LaTeX distribution installed on your system. For Windows, you can install MiKTeX or TeX Live; for macOS, install MacTeX; and for Linux, install TeX Live. After installing the appropriate LaTeX distribution, you can compile your RMarkdown documents into PDF by selecting "Knit to PDF" from the "Knit" drop-down menu in Rstudio.

## **SOFTWARE – Using R Inside Jupyter Notebooks**

To use R inside Jupyter notebooks, first install Jupyter by running the following command in your terminal or command prompt: `pip install jupyter`. Then, install the IRkernel, which is an R kernel for Jupyter, by running the following commands in R: `install.packages('Irkernel')` and `IRkernel::installspec(user = FALSE)`.

Launch Jupyter Notebook by running the following command in your terminal or command prompt: `jupyter notebook`. In the Jupyter interface, you can create a new notebook and select "R" from the available kernels to start using R within the notebook environment

## **SOFTWARE – Getting Started with R**

Basic knowledge of R is a prerequisite for this class. If you have never previously used R, please work through the first section (chapters 1-8) of [“R for Data Science”](#) by Garrett Golemund and Hadley Wickham. While this does not cover time series or forecasting, it will get you used to the basics of the R language, and the tidyverse packages. The [Coursera R Programming](#) course may also be helpful as a refresher. Students will learn how to use R for forecasting through this course.

### **SOFTWARE – Why R**

R and the fpp3 package are used for this course due to their powerful and comprehensive capabilities in time series analysis and forecasting. R is a widely-used statistical programming language that offers an extensive ecosystem of packages and tools specifically designed for data analysis, making it an ideal choice for handling complex time series data. The fpp3 package, which stands for "Forecasting: Principles and Practice" (the third edition), provides a suite of state-of-the-art functions and methodologies aligned with the course textbook. This package simplifies the implementation of various forecasting techniques, including classical decomposition, exponential smoothing, and ARIMA models, while also supporting advanced methods and machine learning approaches. By using R and fpp3, students will gain hands-on experience with industry-standard tools, ensuring they acquire skills that are directly applicable in professional environments, while also allowing for easy transferability of these skills to other platforms like Python.

### **SOFTWARE – Why Jupyter**

In this course, we will use R within Jupyter notebooks to enhance the interactive learning experience. Jupyter notebooks allow you to write and execute R code in a dynamic environment where you can see your results immediately, making it easier to experiment with and understand complex concepts. This setup also helps with documenting your analysis and making your work easily shareable. By combining R's powerful statistical tools with Jupyter's user-friendly interface, we can create a more engaging and effective learning experience for mastering forecasting techniques.

### **SOFTWARE – Why RMarkdown**

In this course, we will use Markdown extensively because it is an extremely powerful tool for preparing clear and comprehensive reports. Assignments, homework, and project reports will require the use of Markdown to effectively document and present your analysis. Markdown allows you to integrate explanatory text, R code, and results within a single, cohesive document. This capability is crucial for creating professional-quality reports, as it enables you to clearly explain your methodology, showcase your findings, and include visualizations and code outputs seamlessly. By using Markdown, you will learn to produce well-organized and polished documents, enhancing your ability to communicate complex analyses effectively. This skill is essential not only for academic success but also for professional development, as it promotes best practices in reproducible research and clear, impactful reporting.

## COURSE FORMAT

All course materials can be found in Brightspace (<https://brightspace.usc.edu/>). Students should ensure that they could access all of the online tools via Brightspace prior to the start of classes. Zoom is the platform used for online office hours. A link and instructions to join the Zoom sessions will be posted in the Brightspace Course Pages.

Students must complete all pre-class assignments before the start of each week's class. Each class meeting will consist of a 1.5-hour lecture followed by a 1.5-hour practical session. In-person attendance and active participation to each class meeting are required.

## EMAIL POLICY

**Email:** Students are kindly asked to follow the email protocol described below, which is useful to reduce response times and ensure effective administration of the class.

- **Use your USC email only.** External emails are often blocked by the spam system.
- **Make sure the subject starts with “DSO 522”.** For example, a good subject line is: “DSO 522 - question about ARIMA”. Emails whose subject follows this format will be automatically placed in a special folder of the instructor's mailbox that receives high priority. Messages that do not follow this format are more likely to get lost.
- If you don't receive a response within 2 business days, please email again.
- If you email a grader, please CC the instructor.

## PARTICIPATION POLICY

In-person class attendance and active participation are essential components of this course. Students are expected to attend all classes. In the event of unforeseen emergencies, students are allowed to miss one class. Students who have to make up for missed classes should write a one-page, double-spaced summary of at least 3 key points that they learned from viewing the recorded class session. Class recordings will be posted in Brightspace within 24 hours of the live class. If there was a group discussion during the class you missed, the make-up assignment should include the relevant discussion questions and their answers.

## GRADING

Grades will be based on quizzes, homework assignments, a midterm exam, and a team project. The weights for each component are given in the table below.

Assignments	% of Overall Grade	Collaboration policy
Pre-class Quizzes	10%	Individual submission
In-Class Participation	10%	Individual submission
Homework Assignments	20%	Individual submission
Midterm Exam	30%	Individual submission
Team Project	30%	Group submission

Final grades represent class performance relative to other students. Historically, the average grade for this class is about a (B+/A-).

**Pre-Class Quizzes:** Preparation for lectures is crucial, as the richness of class discussions and activities largely depends on the degree of preparation by all students. Throughout the semester, there will be short pre-class assignments based on readings and videos, which will be due before each class. These assignments typically involve watching a short video, reading specific materials, and answering follow-up questions. All assignments will be posted on Brightspace, with answers graded based on accuracy. Please read the instructions on Brightspace carefully. Late submissions for pre-class assignments are not accepted, but the lowest pre-class score will be dropped.

**In-Class Participation:** Active participation in class is essential. There will be graded pop-quizzes in class. You will also complete workbooks assigned in class and submit your writeups on Brightspace within 24 hours (by 9:30 pm PST, on the day after). Late submissions will incur a 50% score deduction for the initial delay and an additional 10% deduction for each subsequent business day.

**Homework assignments.** There are four homework assignments in this course, due two weeks after being assigned. These assignments aim to develop skills in understanding and communicating the concepts of time series forecasting. Homework will require you to submit code, provide interpretations, and suggest actionable recommendations. Submissions must be neatly typed with all necessary computer output and graphics appropriately placed. Figures should be clear and readable. While collaboration with classmates is encouraged, all submitted work must be your own. Plagiarism will not be tolerated. Homework is due by 11:59 pm PST on the due date, with a 10% grade reduction for each working day it is late, up to a minimum of 30% of the original grade.

**Midterm Exam:** There will be a midterm exam on October 15, 2024. This exam cannot be retaken.

**Final Project:** The final course project involves analyzing a forecasting data set of your choice in small groups of four. This project includes several key steps:

- Choose teammates by October 15, 2024.
- Submit a one-page project proposal per team by October 22, 2024.
- Submit a deck of 6 slides for your team presentation by December 3, 2024, 11:59 pm PST.
- Submit the project write-up and supporting materials by December 11, 2024, 11:59 pm PST.
- Submit an individual report on your own and your teammates' contributions to the project by December 12, 2024, 11:59 pm PST.

<b>COURSE OUTLINE AND ASSIGNMENTS</b>
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This tentative schedule may be updated before and during the course.

<b>Date</b>	<b>Topic</b>	<b>Chapters</b>	<b>Assignments Due</b>	<b>Assignments Released</b>
08/27/2024 (Week 1)	Introduction to Time Series Analysis Time Series Graphics	1, 2	Quiz 1	
09/03/2024 (Week 2)	Time Series Decomposition	3	Quiz 2	HW 1
09/10/2024 (Week 3)	Time Series Features	4	Quiz 3	
09/17/2024 (Week 4)	The Forecaster's Toolbox	5	Quiz 4 HW 1	
09/24/2024 (Week 5)	The Forecaster's Toolbox	5	Quiz 5	HW 2
10/01/2024 (Week 6)	Time series Regression Models	7	Quiz 6	Project
10/08/2024 (Week 7)	Exponential Smoothing	8	Quiz 7 HW 2	
10/15/2024 (Week 8)	Midterm Exam Hands-on Case Studies		Project Teams	
10/22/2024 (Week 9)	ARIMA Models	9	Quiz 8 Project Proposal	HW 3
10/29/2024 (Week 10)	ARIMA Models	9	Quiz 9	
11/05/2024 (Week 11)	Dynamic Regression Models	10	Quiz 10 HW 3	
11/12/2024 (Week 12)	Hierarchical and Grouped Time Series	11	Quiz 11	HW 4
11/19/2024 (Week 13)	Advanced Forecasting Methods	12	Quiz 12	
11/26/2024 (Week 14)	Practical Forecasting Issues	13	Quiz 13 HW 4	
12/03/2024 (Week 15)	Project Presentations and Discussion		Project Slides	
12/11/2024			Project Writeup	
12/12/2024			Team Report	

The date/time of the Final Exam is determined by the University. For the date and time of the final for this class, consult the USC *Schedule of Classes* at [www.usc.edu/soc](http://www.usc.edu/soc). Select the corresponding semester to view and click on the “Final Examinations Schedule” link on the left side of the screen.

## FEEDBACK

The instructor welcomes constructive student feedback. The student course evaluations are also valuable. This course is continuously improved, based on feedback from students and instructor observations.

## USE OF RECORDINGS

Pursuant to the *USC Student Handbook* (<https://policy.usc.edu/studenthandbook/>, page 27), students may not record a university class without the express permission of the instructor and announcement to the class. In addition, students may not distribute or use notes or recordings based on USC classes or lectures without the express permission of the instructor for purposes other than personal or class-related group study by students registered for the class. This restriction on unauthorized use applies to all information that is distributed or displayed for use in relationship to the class. Violation of this policy may subject an individual or entity to university discipline and/or legal proceedings.

## USE OF AI GENERATORS

**No AI usage permitted.** This course aims to develop creative, analytical, and critical thinking skills. Therefore, all assignments should be prepared by the student working individually or in groups. Students may not have another person or entity complete any substantive portion of the assignment. Developing strong competencies in these areas will prepare you for a competitive workplace. Therefore, using AI-generated text, code, or other content is prohibited in this course, will be identified as plagiarism, and will be reported to the Office of Academic Integrity.

## OPEN EXPRESSION AND RESPECT FOR ALL

*The following text, or an enhanced version, is required by Marshall.*

An important goal of the educational experience at USC Marshall is to be exposed to and discuss diverse, thought-provoking, and sometimes controversial ideas that challenge one's beliefs. In this course we will support the values articulated in the USC Marshall "[Open Expression Statement](https://www.marshall.usc.edu/open-expression-statement)" (<https://www.marshall.usc.edu/open-expression-statement>).



## ACADEMIC INTEGRITY

*The following text, or an enhanced version, is required by Marshall.*

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

Academic dishonesty has a far-reaching impact and is considered a serious offense against the university. Violations will result in a grade penalty, such as a failing grade on the assignment or in the course, and disciplinary action from the university itself, such as suspension or even expulsion.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

*Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment or what information requires citation and/or attribution.*

## STATEMENT ON UNIVERSITY ACADEMIC AND SUPPORT SYSTEMS

*The following text, or an enhanced version, is required by Marshall.*

### **Students and Disability Accommodations:**

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services](#) (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at [osas.usc.edu](https://osas.usc.edu). You may contact OSAS at (213) 740-0776 or via email at [osasfrontdesk@usc.edu](mailto:osasfrontdesk@usc.edu).

### **Student Financial Aid and Satisfactory Academic Progress:**

To be eligible for certain kinds of financial aid, students are required to maintain Satisfactory Academic Progress (SAP) toward their degree objectives. Visit the [Financial Aid Office webpage](#) for [undergraduate](#)- and [graduate-level](#) SAP eligibility requirements and the appeals process.

### **Support Systems:**

[Counseling and Mental Health](#) - (213) 740-9355 - 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages - 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline consists of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) - 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-2500

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 - 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 - 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or [otfp@med.usc.edu](mailto:otfp@med.usc.edu)

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.

## Appendix I. MARSHALL GRADUATE PROGRAMS LEARNING GOALS

*The following text is required by Marshall.*

### How DSO 522 Contributes to Marshall Graduate Program Learning Goals

Marshall Graduate Program Learning Goals	DSO 522 Objectives that support this goal	Assessment Method*
<p><b><i>Learning Goal #1: Develop Personal Strengths.</i></b>  <b>Our graduates will develop a global and entrepreneurial mindset, lead with integrity, purpose and ethical perspective, and draw value from diversity and inclusion.</b></p>		
1.1 Possess personal integrity and a commitment to an organization’s purpose and core values.		
1.2 Expand awareness with a global and entrepreneurial mindset, drawing value from diversity and inclusion.		
1.3 Exhibit awareness of ethical dimensions and professional standards in decision making.		
<p><b><i>Learning Goal #2: Gain Knowledge and Skills.</i></b>  <b>Our graduates will develop a deep understanding of the key functions of business enterprises and will be able to identify and take advantage of opportunities in a complex, uncertain and dynamic business environment using critical and analytical thinking skills.</b></p>		
2.1 Gain knowledge of the key functions of business enterprises.	1-10	Homework Team project
2.2 Acquire advanced skills to understand and analyze significant business opportunities, which can be complex, uncertain and dynamic.	1-10	Homework Team project
2.3 Use critical and analytical thinking to identify viable options that can create short-term and long-term value for organizations and their stakeholders.	1-10	Homework Team project
<p><b><i>Learning Goal #3: Motivate and Build High Performing Teams.</i></b>  <b>Our graduates will achieve results by fostering collaboration, communication and adaptability on individual, team, and organization levels.</b></p>		
3.1 Motivate and work with colleagues, partners, and other stakeholders to achieve organizational purposes.	1-10	Workbooks Team project
3.2 Help build and sustain high-performing teams by infusing teams with a variety of perspectives, talents, and skills and aligning individual success with team success and with overall organizational success.	1-10	Workbooks Team project
3.3 Foster collaboration, communication and adaptability in helping organizations excel in a changing business landscape.	1-10	Workbooks Team project

