Charles H. Dyson School of Applied Economics and Management
Cornell University Fall 2022

AEM 7040:
Applied Macroeconomics

Syllabus

Professor:	Professor C.-Y. Cynthia Lin Lawell
Office hours:	TBA, via Zoom
Teaching Assistant:	Michael Meneses (mam789@cornell.edu)
Office hours:	Monday 1pm-2pm Eastern Time, via Zoom Wednesday 6pm-7pm Eastern Time, via Zoom
Course web site:	Canvas (https://login.canvas.cornell.edu/)
Class time and room:	Thursdays 4:30pm-7:30pm Eastern Time, Warren Hall 150

This Syllabus will be continually updated throughout the Semester. The Canvas course web site will always have the latest version of the Syllabus for this Semester. For the latest version of Syllabus, please see the Canvas course web site.

COURSE DESCRIPTION

AEM 7040 covers analytical concepts and techniques of dynamic analysis, with a focus on optimal control theory as applied to problems in applied macroeconomics. The course also covers macroeconomic applications of these methods that are relevant to the environment, energy, natural resources, agriculture, development, management, finance, marketing, accounting, industrial organization, innovation, entrepreneurship, organizations, technology, and business economics. Topics covered include optimal control theory, capital theory, the maximum principle, the stationary rate of return to capital, investment, dynamic competitive equilibrium, calculus of variations, q-theory, optimal economic growth, optimal savings, optimal growth with pollution, the environmental Kuznets curve, optimal multisector growth, limits to growth, national income accounting, sustainability, natural capital, discounting, structural uncertainty, catastrophes, the dismal theorem, climate change, innovation, endogenous technical change, and productivity.

Prerequisites: Multivariable calculus; differential equations; and graduate-level microeconomics.

Companion courses: Students are encouraged to also take the following complementary companion courses: AEM 7130 (Dynamic Optimization and Computational Methods), AEM 7500 (Resource Economics and Applied Dynamic Structural Econometric Modeling), and AEM 7510 (Environmental Economics). AEM 7040 (Applied Macroeconomics), AEM 7130 (Dynamic Optimization and Computational Methods), AEM 7500 (Resource Economics and Applied Dynamic Structural Econometric Modeling), and AEM 7510 (Environmental Economics) can be taken concurrently and in any order.

LEARNING OUTCOMES

As a result of taking AEM 7040: Applied Macroeconomics, students will be able to:

1. Explain the intuition and logic behind theories and concepts in dynamic analysis.
2. Explain the intuition and logic behind capital theory.
3. Apply techniques of dynamic analysis to problems in applied macroeconomics.
4. Solve dynamic optimization problems using optimal control theory.
5. Apply methods, quantitative tools, and concepts in dynamic analysis, optimal control theory, and capital theory to analyze macroeconomic issues around the world.
6. Articulate, examine, model, and evaluate macroeconomic issues relevant to the environment, energy, natural resources, agriculture, development, management, finance, marketing, accounting, industrial organization, innovation, entrepreneurship, organizations, technology, and business economics.
7. Use optimal control theory to solve and analyze dynamic macroeconomic problems involving the environment, energy, natural resources, agriculture, development, management, finance, marketing, accounting, industrial organization, innovation, entrepreneurship, organizations, technology, and business economics.
8. Use optimal control theory to solve dynamic macroeconomics problems of investment, dynamic competitive equilibrium, q-theory, optimal economic growth, optimal savings, optimal growth with pollution, and optimal multisector growth.
9. Explain, evaluate, and effectively interpret claims, theories, and assumptions related to growth, limits to growth, the environmental Kuznets curve, income, sustainability, natural capital, discounting, structural uncertainty, catastrophes, the dismal theorem, climate change, innovation, endogenous technical change, and productivity.
10. Find, access, critically evaluate, and ethically use information.
11. Identify, locate, collect, construct, organize, manage, describe, and examine time series and panel data sets.
12. Use STATA to manage data sets and perform descriptive empirical analyses.
13. Integrate quantitative and qualitative information to reach defensible and creative conclusions.

14. Communicate and explain difficult concepts, mathematical methods, and quantitative information effectively through writing, speech, and visual information.

15. Apply concepts of sustainability to the analysis of one or more challenges facing humans and Earth's resources.

REQUIRED COURSE MATERIALS

There is no textbook for this class.

Students are required to use Excel. Cornell University students are eligible for several different options for Microsoft Office: https://it.cornell.edu/software-licensing/microsoft-office-students

Students are required to use STATA. STATA is available on Cornell Center for Social Sciences (CCSS) servers: https://socialsciences.cornell.edu/research-support/compute-infrastructure

CODE OF CONDUCT

Students are expected to follow Cornell University's Code of Academic Integrity: https://cuinfo.cornell.edu/aic.cfm

COURSE COPYRIGHT

It is Cornell University policy that faculty members own the copyright of the course materials they develop. Lectures and office hours may not be audio recorded or video recorded except by the instructor. Course materials, problem sets, final projects, lecture recordings, and lecture videos should not be shared, posted, or circulated. Students are not permitted to buy, sell, post, publish, or redistribute any course materials, problem sets, final projects, lecture notes, lecture recordings, or lecture videos. Such unauthorized behavior is a violation of course copyright and constitutes academic misconduct.

TEACHING PHILOSOPHY

Students in this class will be set to a high standard of excellence. This course is very challenging, time- and work-intensive, and demanding, but also very rewarding for students who are willing to work hard and put in the time and effort to attend and actively engage synchronously in lectures and office hours, learn the difficult material, and complete and turn in all their assignments on time.

Teaching, communication, and interactions in this class will follow a high touch approach and the Socratic method. Attendance and participation in class are an integral part of this course.

I encourage you to ask questions and actively participate during class and office hours. I would highly recommend that you come to office hours regularly with your questions, even when there is no problem set due the next day. Between office hours and class, there will be multiple opportunities for you to ask questions before each problem set is due. The dynamically optimal strategy for learning in this class, which I encourage you to follow, is to start working on problem sets early, well before they are due, then come to office hours with your questions, then work more on the problem sets again, and come to office hours again with your questions.

Students are encouraged to ask questions and actively participate during class and office hours. I highly recommend that you come to office hours regularly with your questions. Students who come to class and office hours receive priority for my time and attention. I encourage you to actively participate in class and to come to office hours rather than send me emails when you have questions. As I believe that emails are an inferior means of teaching, communication, and interaction for this course, and as the class will instead follow a high touch approach and the Socratic method, I will not respond to a question by email if it is better addressed in person in office hours. Questions that are better addressed in person in office hours include questions relating to problem sets, questions relating to lectures, questions relating to problem set questions, questions relating to lecture material, analytical questions, empirical questions, questions about data, questions about data sources, questions about graphs, questions about Excel, and questions about STATA. Students should not expect any individual or timely response to any emails that they send to me. This includes all forms of email and email-type messaging, including emails, emails sent via Canvas messaging, emails sent via Zoom, email replies to Canvas messages, and email replies to Zoom messages.

If you would like to ask or talk to me about something, please ask or talk to me in person in class or in office hours. Similarly, if you would like individual and/or timely attention, or would like to communicate or interact with me individually, please come talk to me in person in class or in office hours.

PARTICIPATION

There are 14 lectures in this course. Students are expected to attend all 14 lectures in this course. Attendance and participation in class are an integral part of this course. Critical material and information important for the class, problem sets, and final project are conveyed during lecture and not via any other medium. As explained below, problem sets and the final project are based on the material covered during lecture, and the final project covers material from lectures and problem sets. There is no textbook for this class, nor any other perfect substitute for the learning, discussions, and interactive activities that take place and the material, knowledge, and information conveyed during class.

Participation in this course will be graded out of 28 points total.

There will be at least 2 opportunities to earn a participation point in each of the 14 lectures (Lectures 1-14); some lectures may have more than 2 opportunities to earn a participation point. Since there will therefore be at least 28 opportunities to earn participation points during lecture throughout the semester, students who earn all the participations points in all the lectures will receive the full 28 points out of 28 points total for the participation component of the course. For any lectures that take place over Zoom, in order to earn participation points, please have your video on so that your entire face is visible, and please make sure your audio and microphone are working. Students are encouraged to continue to earn participation points, even after they have received the maximum number of participation points.

Students will receive 1 point for each of Professor Lin Lawell's office hours they attend. Students are encouraged to come to office hours regularly with their questions, even when they have already received the maximum participation points.

Before each lecture, an announcement indicating whether the upcoming lecture will be exclusively in-person or exclusively on Zoom will be posted on the "Announcements" section of the Canvas course web site.

Before each lecture that will be on Zoom, the URL to register for the Zoom meeting for the upcoming lecture will be posted on the "Announcements" section of the Canvas course web site. There will be a separate registration and a different URL for registering for each lecture and a different Zoom meeting (and a different Zoom meeting URL and Zoom meeting ID) for each lecture, so you will need to register separately and again for each lecture, even if you have registered for a previous lecture. Please register using your Cornell email that has your Cornell NetID before "@cornell.edu". Please give yourself at least 1 hour to register for the Zoom meeting in advance of each lecture, so that you are certain to be registered in time to receive the Zoom meeting information, URL, and Zoom meeting ID for joining the Zoom meeting for that lecture, and so that you can join the Zoom meeting in time for the beginning of lecture on Thursdays at 4:30pm Eastern Time.

For the Zoom meetings for both lecture and office hours, please join Zoom on a device that has a camera, a microphone, and audio, so that you can see and hear and can be seen and heard; that has a large enough screen that you can see what is written on the board.

For both in-person and any Zoom lectures, please be prepared to take notes during lecture in the same way you would take notes for an in-person lecture in class (e.g., by writing in your notebook or typing on your computer).

Before each Zoom lecture, be sure to familiarize yourself with Zoom, give yourself enough time to make sure your video and audio works, make sure you have a setup that enables you to see, hear, be seen, be heard, and take notes. Please also familiarize yourself with how to electronically raise your hand in a Zoom meeting. After you join the Zoom meeting, at the bottom of the Zoom window, click on "Reactions"; at the bottom of the menu that pops up there should be a button you can click that enables you to electronically raise your hand in a Zoom meeting.

Lectures are not to be audio recorded or video recorded by anyone except the course instructor.

For lectures that take place in Zoom, in order to attend lecture and participate in class, you must have your video on so that your entire face is visible, and your audio and microphone need to be working. To ask questions during lecture, please electronically raise your hand via Zoom, and wait to be called on.

Students are encouraged to ask questions and actively participate during class and office hours, even when they have already received the maximum participation points, and even when they do not receive additional participation points for doing so.

As AEM 7040 is an advanced Ph.D. class, and as fully engaging during all lectures; working hard on all the problem sets; and studying, reviewing, and synthesizing the material for the final project will be critical for learning the technical and abstract material in this class, auditors are not permitted in this course. Students must register and enroll in this course for a letter grade.

Participation in this course will be graded out of 28 points total. Each participation point up to the maximum 28 participation points will be equally weighted, each constituting 1/28th of the total participation grade for this course.

PROBLEM SETS

There will be 6 problem sets in this course. Problem sets will be posted on the Canvas course web site. These problem sets are designed to familiarize students with the methods and concepts introduced in class; to help students develop the creative and critical thinking skills needed for research in the area; and to guide students toward achieving the learning outcomes for this course.

Please upload and submit your homework assignments and code in a zipped file onto the course web site before the beginning of class **by noon Eastern Time** the day they are due. No extensions will be granted.

The zipped file should be named "<*Lastname*>_<*Firstname*>_PS<#>.zip", and should include a write-up of the answers in a pdf file entitled "<*Lastname*>_<*Firstname*>_PS<#>_answers.pdf", as well as any Excel files, STATA data sets, STATA do files, and STATA log files each as separate files. The writeup should be in pdf format, and should include all graphs, results, tables, etc. STATA code should be in STATA do files (.do files) in plain text format. Please comment your code and include a "READ_ME" document that specifies how to run the code and which program does what. Include any STATA data sets as ".dta" files. For example, George F. Warren's Problem Set 1 would be in a zipped folder with the name "Warren_George_PS1.zip". Similarly, Teng-hui Lee's Problem Set 2 would be in a zipped folder with the name "Lee_Teng-hui_PS2.zip".

The online submission for problem sets is through Canvas, in the same "Assignments" section of the Canvas course web site where the problem sets are posted. There will be one item per problem set, and this item includes the problem set itself as well as the portal for submission. For example, the portal for submitting the first problem set online can be accessed by clicking "Problem Set 1" in the "Assignments" section of the Canvas course web site.

Students may submit their problem sets multiple times online if they would like. For each problem set, the last version of problem set submitted online will be counted as what you have submitted online for that problem set, and will override any previous submissions of that problem set (even if a previous version may have earned you a higher score). The last version of problem set submitted online must therefore be submitted online **by noon Eastern Time** the day it is due, regardless of whether a previous version of that problem sets was submitted on time.

If the last version of the problem set submitted online is submitted (and received) online past the **noon Eastern Time** deadline the day it is due, minutes and seconds late will be rounded up to the next whole hour and 10 points will be automatically deducted for each hour the problem set is late. For example, if the last version of the problem set is submitted and received online at 12:01pm Eastern Time the day it is due, then 10 points will be deducted from the problem set score. Similarly, if the last version of the problem set is submitted and received online at 1:01pm Eastern Time the day it is due, then 20 points will be deducted from the problem set score. Likewise, if the last version of the problem set is submitted and received online at 2:01pm Eastern Time the day it is due, then 30 points will be deducted from the problem set score. If the last version of a problem set is submitted 9:00pm Eastern Time or later the day it is due (i.e., if the last version of a problem is submitted more than 9 hours after it is due), or if the problem set is never submitted online, then 0 points will be given for the problem set. The deductions for late submissions are made automatically by Canvas, and are based on the clock used by Canvas. Students are encouraged to submit their problem sets well ahead of time, so that any difficulty with the submission, internet congestion, internet connectivity, time zones, and/or differences in the clock used by Canvas and their own clock, etc., will not cause their problem set submission to be submitted (and received) online past the **noon Eastern Time** deadline and marked and penalized as Late by Canvas. No extensions will be granted.

Students may consult each other on problem sets, but each student must complete and write up each of his or her problem sets separately on his or her own. Each student's problem set should therefore be unique and different from problem sets submitted by other students in the class, and also different from problem sets, final projects, or final exams submitted by students in previous classes or in other classes.

The 6 problem sets will be equally weighted, each constituting 1/6th of the total problem set grade for this course.

FINAL PROJECT

There will be a final project that is due at the end of the semester. The final project covers all lectures (Lectures 1-14) and all problem sets (Problem Sets 1-6), and will be posted on the Canvas course web site after Lecture 14.

The final project must be submitted online by **Thursday, December 15, 2022 at noon Eastern Time**. No extensions will be granted.

Please upload and submit your final project and code in a zipped file onto the course web site. The zipped file should be named "<*Lastname*>_<*Firstname*>_FinalProject.zip", and should include a write-up of the answers in a pdf file entitled "<*Lastname*>_<*Firstname*>_FinalProject_answers.pdf", as well as all the source files for the write-up (i.e., all tex and .bib files for all parts of the write-up in LaTex; all Word files for all parts of the write-up in Word; and all figure files), any Excel files, STATA data sets, STATA do files, STATA log files, and STATA figure files each as separate files. The writeup should be in pdf format, and should include all graphs, results, tables, etc. STATA code should be in STATA do files (.do files) in plain text format. Please comment your code and include a "READ_ME" document that specifies how to run the code and which program does what. Include any STATA data sets as ".dta" files. For example, Barbara McClintock's final project would be in a zipped folder with the name "McClintock_Barbara_FinalProject.zip". Similarly, Kenneth L. Robinson's final project would be in a zipped folder with the name "Robinson_Kenneth_FinalProject.zip".

The online submission for the final project is through Canvas, in the same "Assignments" section of the Canvas course web site where the final project posted. There will be one item for the final project, and this item includes the final project itself as well as the portal for submission. The portal for submitting the final project online can be accessed by clicking "Final Project" in the "Assignments" section of the Canvas course web site.

Students may submit their final project multiple times online if they would like. The last version of the final project submitted online will be counted as what you have submitted online for the final project, and will override any previous submissions of the final project (even if a previous version may have earned you a higher score). The last version of final project submitted online must therefore be submitted online by **Thursday, December 15, 2022 at noon Eastern Time**, regardless of whether a previous version of that final project was submitted on time.

If the last version of the final project submitted online is submitted (and received) online past the deadline the day it is due, minutes and seconds late will be rounded up to the next whole hour and 10 points will be automatically deducted for each hour the final project is late. The deductions for late submissions are made automatically by Canvas, and are based on the clock used by Canvas. Students are encouraged to submit their final project well ahead of time, so that any difficulty with the submission, internet congestion, internet connectivity, time zones, and/or differences in the clock used by Canvas and their own clock, etc., will not cause their final project submission to be submitted (and received) online past the deadline and marked and penalized as Late by Canvas. No extensions will be granted.

Students may consult each other on the final project, but each student must complete and write up each of his or her final project separately on his or her own. Each student's final project should therefore be unique and different from final projects and problem sets submitted by other students in the class, and also different from final projects, final exams, and problem sets submitted by students in previous classes or in other classes.

GRADING

Participation:	28%
Problem sets:	60%
Final project:	12%

As AEM 7040 is an advanced Ph.D. class, and as fully engaging during all lectures; working hard on all the problem sets; and studying, reviewing, and synthesizing the material for the final project will be critical for learning the technical and abstract material in this class, auditors are not permitted in this course. Students must register and enroll in this course for a letter grade.

CLASS SCHEDULE

Date	Problem Set Due (noon)	Topic
Thu 8/25		**Lecture 1: Introduction to Capital Theory and Dynamic Optimization** Intriligator, Michael D. (1971). Mathematical Optimization and Economic Theory. Englewood Cliffs, NJ: Prentice Hall. Kamien, Morton I., and Nancy L. Schwartz. (1991). Dynamic Optimization. 2nd Edition. New York: Holland. Weitzman, Martin L. (2003). Income, Wealth, and the Maximum Principle. Cambridge, MA: Harvard University Press. Acemoglu, Daron. (2009). Introduction to Modern Economic Growth. Princeton, NJ: Princeton University Press. Conrad, Jon M. (2010). Resource Economics. 2nd Edition. Cambridge, UK: Cambridge University Press. Kaiser, Harry M., and Kent D. Messer. (2011). Mathematical Programming Models for Agricultural, Environmental and Resource Economics. Hoboken, NJ: John Wiley and Sons, Inc.

Thu 9/1		**Lecture 2: Optimal Control Theory** Pontryagin, Lev S., Vladimir G. Boltyanskii, Revaz V. Gamkrelidze, and Evgeni F. Mishchenko. (1962). The Mathematical Theory of Optimal Processes. New York: Wiley Interscience. Kamien, Morton I., and Nancy L. Schwartz. (1991). Dynamic Optimization. 2nd Edition. New York: Holland. Weitzman, Martin L. (2003). Income, Wealth, and the Maximum Principle. Cambridge, MA: Harvard University Press. Acemoglu, Daron. (2009). Introduction to Modern Economic Growth. Princeton, NJ: Princeton University Press. Conrad, Jon M. (2010). Resource Economics. 2nd Edition. Cambridge, UK: Cambridge University Press. Conrad, Jon M., and Daniel Rondeau. (2020). Natural Resource Economics: Analysis, Theory, and Applications. Cambridge, UK: Cambridge University Press.

Labor Day		----- *Labor Day* -----

Thu 9/8		**Lecture 3: Maximum Principle and Dynamic Competitive Equilibrium** Pontryagin, Lev S., Vladimir G. Boltyanskii, Revaz V. Gamkrelidze, and Evgeni F. Mishchenko. (1962). The Mathematical Theory of Optimal Processes. New York: Wiley Interscience. Dorfman, Robert. (1969). An economic interpretation of optimal control theory. American Economic Review, 59, 817-831. Seierstad, Atle, and Knut Sydsaeter. (1977). Sufficient conditions in optimal control theory. International Economic Review, 18 (2), 367-391. Weitzman, Martin L. (2003). Income, Wealth, and the Maximum Principle. Cambridge, MA: Harvard University Press. Acemoglu, Daron. (2009). Introduction to Modern Economic Growth. Princeton, NJ: Princeton University Press.

Thu 9/15	PS 1 due (noon)	**Lecture 4: Most Rapid Approach Policy** Spence, A. Michael, and David A. Starrett. (1975). Most rapid approach paths in accumulation problems. International Economic Review, 16, 388-403. Weitzman, Martin L. (2003). Income, Wealth, and the Maximum Principle. Cambridge, MA: Harvard University Press.

Thu 9/22		**Lecture 5: Adjustment Costs to Net Investment** Tobin, James. (1969). A general equilibrium approach to monetary theory. Journal of Money, Credit and Banking, 1 (1), 15-29. Yoshikawa, Hiroshi. (1980). On the "q" theory of investment. American Economic Review, 70 (4), 739-743 Weitzman, Martin L. (2003). Income, Wealth, and the Maximum Principle. Cambridge, MA: Harvard University Press. Acemoglu, Daron. (2009). Introduction to Modern Economic Growth. Princeton, NJ: Princeton University Press. Romer, David. (2011). Advanced Macroeconomics. 4th Edition. New York: McGraw-Hill. Steiner, Eva. (2017). REIT capital structure: The value of getting it right. Cornell Hospitality Report, 17 (13), 3-13. Faria, João Ricardo, Greg Tindall, and Siri Terjesen. (2022). The green Tobin's q: Theory and evidence. Energy Economics, 110, 106033. Begenau, Juliane, Saki Bigio, Jeremy Majerovitz, and Matias Vieyra. (2020). A q-theory of banks. NBER Working Paper No. 27935. URL: https://www.nber.org/papers/w27935 Dai, Min, Xavier Giroud, Wei Jiang, and Neng Wang. (2021). A q theory of internal capital markets. NBER Working Paper No. 27931. URL: https://www.nber.org/papers/w27931

Thu 9/29	PS 2 due (noon)	**Lecture 6: Ramsey-Cass-Koopmans Model of Optimal Economic Growth** Ramsey, Frank P. (1928). A mathematical theory of saving. Economic Journal, 38 (152), 543-559. Cass, David. (1965). Optimum growth in an aggregate model of capital accumulation. Review of Economic Studies, 32, 233-240. Koopmans, Tjalling C. (1965). Paper presented at the Vatican Study Week on the Econometric Approach to Development Planning, Rome, Pontifical Academy of Science, 7-13 October, pp. 225-300. Mankiw, N. Gregory, David Romer, and David N. Weil. (1992). A contribution to the empirics of economic growth. Quarterly Journal of Economics, 107 (2), 407-437. Quah, Danny. (1997). Empirics for growth and distribution: Stratification, polarization and convergence clubs. Journal of Economic Growth, 2, 27-60. Weitzman, Martin L. (2003). Income, Wealth, and the Maximum Principle. Cambridge, MA: Harvard University Press. Barro, Robert J., and Xavier I. Sala-i-Martin. (2003). Economic Growth. 2nd Edition. Cambridge, MA: MIT Press. Helpman, Elhanan. (2005). Mystery of Economic Growth. Cambridge, MA: Harvard University Press. Acemoglu, Daron. (2009). Introduction to Modern Economic Growth. Princeton, NJ: Princeton University Press. Marcos D. Chamon, and Eswar S. Prasad. (2010). Why are saving rates of urban households in China rising? American Economic Journal: Macroeconomics, 2 (1), 93-130. Bogan, Vicki L. (2015). Household asset allocation, offspring education, and the sandwich generation. American Economic Review, 105 (5), 611-615. Chirinko, Robert S., and Debdulal Mallick. (2019). International capital allocations and the Lucas Paradox redux. CESifo Working Paper No. 7796. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3468028 Benigno, Gianluca, Huigang Chen, Christopher Otrok, Alessandro Rebucci, and Eric R. Young. (2019). Optimal policy for macro-financial stability. NBER Working Paper No. 26397. URL: https://www.nber.org/papers/w26397 Irmen, Andreas, and Amer Tabakovic. (2020). Factor income distribution and endogenous economic growth: Piketty meets Romer. Economic Inquiry, 58 (3), 1342-1361.

Startz, Richard. (2020). The next hundred years of growth and convergence. Journal of Applied Econometrics, 35 (1), 99-113.

Galimberti, Jaqueson K. (2020). Forecasting GDP growth from outer space. Oxford Bulletin of Economics and Statistics, 82 (4), 697-722.

Ha-Huy, Thai, Cuong Le Van, and Thi-Do-Hanh Nguyen. (2020). Optimal growth when consumption takes time. Journal of Public Economic Theory, 22 (5), 1442-1461.

Baumeister, Christiane, and Pierre Guérin. (2021). A comparison of monthly global indicators for forecasting growth. International Journal of Forecasting, 37 (3), 1276-1295.

Fezzi, Carlo, and Valeria Fanghella. (2021). Tracking GDP in real-time using electricity market data: Insights from the first wave of COVID-19 across Europe. European Economic Review, 139, 103907.

Spiro, Daniel. (2021). An open-economy Ramsey-Cass-Koopmans model in reduced form. CESifo Working Paper No. 9293. URL: https://ssrn.com/abstract=3925325

Jacobs, Jan P.A.M., Samad Sarferaz, Jan-Egbert Sturm, and Simon van Norden. (2022). Can GDP measurement be further improved?: Data revision and reconciliation. Journal of Business and Economic Statistics, 40 (1), 423-431.

Prados de la Escosura, Leandro. (forthcoming). Inequality beyond GDP: A long view. Review of Income and Wealth.

Müller, Ulrich K., James H. Stock, and Mark W. Watson. (forthcoming). An econometric model of international growth dynamics for long-horizon forecasting. Review of Economics and Statistics.

Burger, John D., Francis E. Warnock, and Veronica Cacdac Warnock. (forthcoming). A natural level of capital flows. Journal of Monetary Economics.

Hulten, Charles R., and Leonard I. Nakamura. (2022). Is GDP becoming obsolete?: The "Beyond GDP" debate. NBER Working Paper 30196. URL: https://www.nber.org/papers/w30196

Thu 10/6		**Lecture 7: Optimal Growth with Pollution and Environmental Kuznets Curve**

Kuznets, Simon. (1955). Economic growth and income inequality. American Economic Review, 45: 1-28.

Kuznets, Simon. (1965). Economic Growth and Structural Change. New York: Norton.

Grossman, Gene M., and Alan B. Krueger. (1995). Economic growth and the environment. Quarterly Journal of Economics, 110 (2), 353-377.

Stokey, Nancy L. (1998). Are there limits to growth? International Economic Review, 39 (1), 1-31.

Peterson, Jeffrey M., Richard N. Boisvert, and Harry de Gorter. (2002). Environmental policies for a multifunctional agricultural sector in open economies. European Review of Agricultural Economics, 29 (4), 423-443.

Basu, Arnab K., Nancy H. Chau, and Ulrike Grote. (2003). Eco-labeling and stages of development. Review of Development Economics, 7 (2), 228-247.

Israel, Debra, and Arik Levinson. (2004). Willingness to pay for environmental quality: Testable empirical implications of the growth and environment literature. The B.E. Journal of Economic Analysis & Policy: Contributions, 3(1), 1-31.

Weitzman, Martin L. (2003). Income, Wealth, and the Maximum Principle. Cambridge, MA: Harvard University Press.

Aldy, Joseph E. (2007). Energy and carbon dynamics at advanced stages of development: An analysis of the U.S. states, 1960–1999. Energy Journal, 28 (1), 91-111.

Brock, William A., and M. Scott Taylor. (2010). The green Solow model. Journal of Economic Growth, 15 (2), 127-153.

Conrad, Jon M. (2010). Resource Economics. 2nd Edition. Cambridge, UK: Cambridge University Press.

Fischer, Carolyn, and Garth Heutel. (2013). Environmental macroeconomics: Environmental policy, business cycles, and directed technical change. Annual Review of Resource Economics, 5, 197-210

Lin, C.-Y. Cynthia, and Zachary D. Liscow. (2013). Endogeneity in the environmental Kuznets curve: An instrumental variables approach. American Journal of Agricultural Economics, 95 (2), 268-274.

Lin Lawell, C.-Y. Cynthia, Krishna P. Paudel, and Mahesh Pandit. (2018). One shape does not fit all: A nonparametric instrumental variable approach to estimating the income-pollution relationship at the global level. Water Resources and Economics, 21, 3-16.

Kanbur, Ravi. (2019). Structural transformation and income distribution: Kuznets and beyond. In Célestin Monga and Justin Yifu Lin (Eds.), The Oxford Handbook of Structural Transformation (pp. 96-108). Oxford, UK: Oxford University Press.

Levinson, Arik, and James O'Brien. (2019). Environmental Engel curves: Indirect emissions of common air pollutants. Review of Economics and Statistics, 101 (1). 121-133.

Bouché, Stéphane, and Carlos de Miguel. (2019). Endogenous aspirations, growth and the rise of environmental concerns. Energy Economics, 84 (Supplement 1), 104526.

Shahbaz, Muhammad, Muhammad Shafiullah, Usman Khalid, and Malin Song. (2020). A nonparametric analysis of energy environmental Kuznets Curve in Chinese Provinces. Energy Economics, 89, 104814.

Awaworyi Churchill, Sefa, John Inekwe, Kris Ivanovski, and Russell Smyth. (2020). The Environmental Kuznets Curve across Australian states and territories. Energy Economics, 90, 104869.

Lo Bue, Maria C., and Flaviana Palmisano. (2020). The individual poverty incidence of growth. Oxford Bulletin of Economics and Statistics, 82 (6), 1295-1321.

Jin, Wei, Rick van der Ploeg, and Lin Zhang. (2020). Do we still need carbon-intensive capital when transitioning to a green economy? CESifo Working Paper No. 8745. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3744608

Montalvo, José G., and Marta Reynal-Querol. (2021). Ethnic diversity and growth: Revisiting the evidence. Review of Economics and Statistics, 103 (3), 521-532.

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Fall Break		----- *Fall Break* -----

Thu 10/13	PS 3 due (noon)	**Lecture 8: Optimal Multisector Growth**

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Thu 10/27	PS 4 due (noon)	**Lecture 10: Income and Sustainability**

Lecture 10: Income and Sustainability

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Thu 11/10	PS 5 due (noon)	**Lecture 12: Structural Uncertainty, Catastrophes, and the Dismal Theorem**

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Thu 11/17		**Lecture 13: Innovation, Resources, the Environment, and Agriculture**

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Thanks giving		----- *Thanksgiving Break* -----

Thu 12/1	PS 6 due (noon)	**Lecture 14: Synthesis, Final Project Review, and Conclusion**

Thu 12/15	Final project due (noon)	***Final Project due Thursday, December 15, 2022 at noon Eastern Time***

SUMMARY

Date	Problem Set Due (noon)	Topic
Thu 8/25		**Lecture 1: Introduction to Capital Theory and Dynamic Optimization**
Thu 9/1		**Lecture 2: Optimal Control Theory**
Labor Day		----- *Labor Day* -----
Thu 9/8		**Lecture 3: Maximum Principle and Dynamic Competitive Equilibrium**
Thu 9/15	PS 1 due (noon)	**Lecture 4: Most Rapid Approach Policy**

Thu 9/22		**Lecture 5: Adjustment Costs to Net Investment**
Thu 9/29	PS 2 due (noon)	**Lecture 6: Ramsey-Cass-Koopmans Model of Optimal Economic Growth**
Thu 10/6		**Lecture 7: Optimal Growth with Pollution and Environmental Kuznets Curve**
Fall *Break*		----- *Fall Break* -----
Thu 10/13	PS 3 due (noon)	**Lecture 8: Optimal Multisector Growth**
Thu 10/20		**Lecture 9: Limits to Growth**
Thu 10/27	PS 4 due (noon)	**Lecture 10: Income and Sustainability**

Thu 11/3		**Lecture 11: Discounting**
Thu 11/10	PS 5 due (noon)	**Lecture 12: Structural Uncertainty, Catastrophes, and the Dismal Theorem**
Thu 11/17		**Lecture 13: Innovation, Resources, the Environment, and Agriculture**
Thanks giving		----- *Thanksgiving Break* -----
Thu 12/1	PS 6 due (noon)	**Lecture 14: Synthesis, Final Project Review, and Conclusion**
Thu 12/15	Final project due (noon)	***Final Project due Thursday, December 15, 2022 at noon Eastern Time***

updated December 1, 2022