Agricultural Economics 689
Special Topics in Agricultural Economics: Dynamic Optimization
Fall 2013, Mon. 9:10 – 11:10, AGLS 110

Instructor
Richard Woodward
210M AGLS Building
Office: 979-845-5864
Home: 979-703-6470
r-woodward@tamu.edu
Skype: Richard_T_Woodward

Office Hours and communication
• Open door policy
• e-mail messages usually receive prompt response.
• If necessary, you may call me at home, but please not after 9:00.

I. Course Objectives
• To develop an intuitive understanding of dynamic economic problems including (discrete and continuous, deterministic and stochastic).
• To understand applications of dynamic economic analysis in the areas of agricultural and natural resource economics.
• To be able to read and understand papers in which dynamic optimization plays a central role.
• To become competent in the process of setting up and solving dynamic optimization problems, both analytically and numerically, and to understand the strengths and weaknesses of alternative methods.

II. Class home page
The class homepage is located at http://agecon2.tamu.edu/people/faculty/woodward-richard/637/.
Notes, problem sets and other information relevant to the course will be available there. I will provide notes for each lecture on the web site at least 48 hours prior to each class. If notes are not posted by this time, contact me because it is likely that there has been a computer glitch. If for some reason I fail to post the notes at that time, I will supply printed copies in class.

III. Prerequisites
It will be assumed that you have a very strong understanding of calculus (constrained optimization and integration), linear algebra and fundamental principles of probability and statistics. You must also be comfortable with the basic microeconomic results of consumer and producer theory. Previous exposure to differential equations would be helpful, but is not assumed. Economics 629 and Econometrics 669 together satisfy the prerequisites.

IV. Grading
The grading system to be used this year will be very different. You will be given a list of basic, intermediate and advanced skills that you should strive to master during the course.
For a C: A student must demonstrate mastery of all basic concepts in all categories.
For a B: A student must demonstrate mastery all intermediate topics in Group I (general issues in dynamic optimization) plus at least 75% of the intermediate concepts in the other categories.
For an A: A student must demonstrate mastery of at least 90% all intermediate concepts and mastery of at least 75% of the advanced topics in either OC or NDP.
For an A with letter to be included in the student’s permanent file. At least 75% of the advanced topics in both Groups II and II (optimal control and numerical dynamic programming).
Mastery of basic concepts will be demonstrated by correctly answers 100% of a set of multiple choice questions on that topic. After one attempt, a student may be retested on that concept after a delay of at least 3 days. Retakes may be administered through an oral or short answer questions at the discretion of the instructor.

Mastery of intermediate concepts will be demonstrated by correctly answering short answer questions. A student may be retested on an intermediate concept, but at intervals of at least one week. Exceptions may be made to this at the end of the semester. Students will be allowed only one attempt to demonstrate mastery on an intermediate concept after the last day of class.

Mastery of advanced concepts will be demonstrated by solving problems or through a discussion with the instructor. Students will be allowed only one attempt to demonstrate mastery on an advanced concept after the last day of class.

Mastery evaluations must be scheduled at least 24 hours in advance. Students should allow about 10 minutes per basic concept and longer times for more advanced concepts.

Working with others: Anything you hand in for this class must reflect your own understanding. However, as you develop mastery in the many concepts covered in this class, you are strongly encouraged to work with others.

It is a violation of the honor code to reveal the specific contents of any of the tests that are used to demonstrate mastery.

V. Homeworks

There will be three homeworks but these will not be graded. A student may request the answer key at any time. A mastery evaluation on a topic cannot be requested until the corresponding homework problems have been completed and turned in.

VI. Team-based Learning

In this class we will use team-based learning in which class time is spent primarily working on problems with members of a team with whom you will work all semester. There will be no standard lectures. Instead, you will be required to read and study the notes for each class prior to arriving each day and then we will engage the material and take it to a higher level in class.

Several times during the semester we will start the class with surprise “Readiness Assessment Tests (RATs) in which you answer a few multiple-choice questions first individually the (iRAT) and then as a team (tRAT).

Most days we will start each class (or after the RAT on days when one is given) by answering questions on the day’s notes. By 8:00 a.m. each Monday, all students must submit 1-3 questions on the lecture notes that they would like to have answered in the class discussion. Each team will then select the most pressing questions to be answered and we will answer as many as possible each day. On some days, teams will work on exercises designed to help you engage material in the lecture notes and prepare for the mastery tests.

Teammates will carry out a peer evaluation of each other twice during the semester.

Peer evaluation scores, and RAT scores will be used to inform my decisions on borderline grades.

In the event that there is insufficient preparation for classes and/or participation in team-based activities, the grading rubric outlined above will be adjusted to provide stronger incentives.
VII. Computer programming

The use of computers is central to much of applied economic analysis and will play a major role in this course. The only way to learn a foreign language is by practicing. The same rule holds for programming languages. I believe that you should look at each course you take as an opportunity to learn a new language. The more languages you "speak," the more flexibility that you have as you try to solve a problem. On the other hand, learning a language can be time consuming and get in the way of learning the economic concepts that are the focus of the course. So you must balance the associated benefits and costs based on your own interests, time constraints and talents.

We will have computer labs during which students I will be available to assist in the use of programming languages that will be used to complete the homework assignments.

All of the computer homework assignments can, at least in theory, be completed using any one of a number of programs including GAMS, Fortran, Gauss, Matlab, or Visual Basic. Some of the problems could even be solved in Excel or other spreadsheets. You may use almost any program language to complete the assignments for this course. However, the default language for the dynamic programming part of this course will be Visual Basic. VB is used because it is readily accessible (if you have Excel, you have VB), its syntax is quite easy to learn, it integrates easily with the graphing and analytical capabilities of Excel, and it provides a nice stepping stone to other languages. We will have several sessions in which we spend some time working in the computer lab. There are a number of books that will help you learn to program, including the book by Albright noted below.

I encourage you to use languages other than VB, but if you want to do so, please discuss it with me to make sure that it will work.

VIII. Outline of the course (This outline is substantive, not sequential)

A. Nature of Dynamics
B. Optimal control theory
   1. Derivation of optimal control necessary conditions, Hamiltonians
   2. Finite horizon problems
   3. Infinite horizon problems
   4. Economic Interpretation
   5. Bang-bang and most-rapid-approach-path solutions to optimal control
   6. Stochastic optimal control (Ito calculus) (we usually don’t get to this)
C. Dynamic Programming
   1. Deterministic DP
   2. Stochastic DP
   3. Infinite horizon problem and convergence
D. Dynamic programming in planning, management and positive analysis
   1. Using DP in econometric analysis
   2. Integrating DP with large simulation models

IX. Texts

The following are optional texts and should be available at the book store. I would not recommend buying all of these books as the cost would be excessive and there is some repetition. You are welcome to look at my copies of these books before making a decision and copies of some books are available for loan. For the nuts and bolts of numerical dynamic programming, excellent available references are the chapter by Rust (Handbook of Computational Economics), the text by Miranda and Fackler, and a few chapters of the book by Judd. If you have not done a lot of programming, then the
Albright or Miranda and Fackler texts might be helpful, depending on whether you intend to do the programming assignments in VB or Matlab.

**Optimal Control**


**Dynamic Programming & Numerical Methods**


**VB Programming**

X. **Acknowledgments**
In developing the material for this course I draw on numerous sources, and I want to give the authors credit. As a general disclaimer, I claim the discovery of none of the material covered in the course. If you are unsure of the source for the material that I am presenting, simply ask and I will normally gladly provide the necessary citation, at least after the problem set has been handed in. Unpublished sources that I will draw on include:

Karp, Larry. Lecture notes on Methods of Dynamic Analysis and Control. University of California, Berkeley


XI. **Students with disabilities**
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities, be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. Texas A&M University has a strong institutional commitment to the principle of diversity in all areas. In that spirit, admission to Texas A&M University and any of its sponsored programs is open to all qualified individuals without regard to subgroup, class or stereotype.

If you believe you have a disability requiring an accommodation, please contact the Department of Disability Services in Room B118 of the Cain Hall Building. The phone number is 845-1637. ADA accommodations will be made in accordance with the law.
Key Concepts in Richard Woodward’s Dyn. Optimization Course

The grade you receive in the course is related to your ability to master basic, intermediate and advanced skills.

I. General issues in dynamic optimization
   
   A. Basic skills
      1. Identify the key variables and functions in a problem: state, control & intermediate in a general problem statement. (PS1.1)
      2. Define the key functions: Benefit function, state equation, objective function, and salvage value in a general problem statement. (PS1.2)
      3. Be able to write a computer program that would carry out the tasks indicated on the Quiz included in the VB tutorial. (VB Tutorial)

   B. Intermediate skills
      1. Explain the commonalities and differences between optimal control and dynamic programming.

   C. Advanced skills
      1. Independently develop a well-defined dynamic optimization problem with reasonable sets of key variables and functions.
      2. Clearly convert a problem from a DP to OC specification and vice versa and explain the commonalities and differences.

II. Optimal control (continuous time & analytical solutions)

   A. Basic skills
      1. Solve a very simple (constant or single variable) first-order differential equation. (PS1.3)
      2. Explain in words what a differential equation means (of any order). (PS1)
      3. Solve differential equations using a symbolic algebra program. (PS1.3)
      4. Take a clearly defined dyn. opt. problem and write down the Hamiltonian and FOCs. (PS2)
      5. Derive the transversality condition for a vertical end-point problem. (PS2)
      6. Reformulate a present-value OC problem to a current-value specification and vice versa. (PS2.4)

   B. Intermediate skills
      1. Solve a linear first-order differential equation. (PS1.3)
      2. Correctly develop a phase diagram given the appropriate differential equations, including identifying the equilibrium. (PS1.4)
      3. Describe a phase diagram or set of differential equations in terms of stability and trajectories. (PS2)
      4. Take a general problem and write down the Hamiltonian and FOCs. (PS2)
      5. Given a general problem statement, identify the type of end-point problem that it is and correctly state the transversality condition. (PS2)
      6. Provide economic interpretation of the FOC w.r.t. the control variable (present & current value). (PS2)
      7. Set up a constrained dyn. optimization problem and derive the FOCs. (Lecture 14)
C. Advanced skills
1. Correctly solve a system of equations to reach a set of differential equations, present them in a graph, and interpret the graph. (Lecture 2)
2. Solve a relatively simple constrained optimal control problem. (Lecture 14)
3. Evaluate analytically and/or numerically the stability of a system of nonlinear differential equations. (PS1.4)
4. Given a general problem statement, provide the correct formal statement of the problem, solve the problem (to the extent that a solution is possible), and use appropriate mathematical and graphical skills to describe the solution to the problem. (PS2)
5. Provide strong economic intuition for optimal trajectories using the FOCs. (PS2)
6. Derive the correct transversality condition for any general problem using both a present- and current-value specification, including problems with salvage value and infinite-horizon problems. (PS2)
7. Provide economic interpretation of the FOC w.r.t. the state variable for both present & current value specifications. (PS2)
8. Provide intuitive economic interpretation of a Hamiltonian. (PS2)
9. Solve a constrained dynamic optimization problem including MRAP and bang-bang type problems. (Lecture 14)
10. Set up and solve a relatively simple stochastic control problem. (Lecture 14)

III. Numerical dynamic programming (discrete time & numerical solutions)
A. Basic skills
1. Set up and solve a well-defined deterministic DD-DP problem using a circle-and-arrow approach. (PS3.2)
2. Write down the Bellman’s equation for a well-specified dynamic optimization problem. (PS3.2)
3. Write down pseudo code that would be used to solve a finite-horizon one-dimensional DD-DP problem. (PS3.2)
4. Write a computer program to numerically solve a deterministic finite-horizon one-dimensional DD-DP problem. (PS3.3)
5. Write computer code that generates the optimal path that follows from the solution to a deterministic finite-horizon one-dimensional DD-DP problem and explain the path. (PS3.3)
6. Set up a Markov transition matrix, and find the transition probabilities over \( n \) periods and as \( n \to \infty \). (Lecture 9)

B. Intermediate skills
1. Set up and solve a well-defined stochastic DD-DP problem using a circle-and-arrow approach. (Lecture 7)
2. Write down the Bellman’s equation for a general problem statement for a DD problem. (PS3)
3. Present graphically and economically interpret the policy function and value function that results from any DP problem. (PS3)
5. Write a computer program that solves a deterministic infinite horizon DD-DP. (PS3.4)
6. Write computer code that generates the optimal path that follows from the solution to a deterministic infinite-horizon DD-DP problem and explain the path. (PS3.3)
7. Write a computer program that solves a deterministic CD-DP problems using rounding or linear interpolation. (PS3.4)
8. Write a computer program that solves a stochastic DD-DP problems (PS3.5)
9. Calculate and economically interpret the probabilistic outcomes of a stochastic DP problem (PS3.5)
10. Write computer code that generates the optimal paths that follows from the solution to a stochastic DD-DP problem and explain and analyze the paths and the solution to the problem. (PS3.5)
11. Solve analytically a simple DP problem with a continuous choice variable. (PS3.1)

C. Advanced skills
1. Write a computer program that solves a stochastic infinite horizon DD-DP. (PS3.5)
2. Write a computer program that solves a deterministic CC-DP problems using hill-climbing algorithms. (Lecture 11)
3. Write a computer program that solves a problems with multiple state variables.
4. Demonstrate the ability to use policy iteration and another acceleration technique for the solution of \(\infty\)-horizon problems. (PS3.5)
5. Demonstrate the ability to use nonlinear interpolation and spline methods for problems with continuous state variables. (Lecture 11)
6. Describe in general terms how Rust’s nested fixed point algorithm would be used to estimate the parameters of a dynamic decision problem. (Lecture 13)