

THE GEORGE WASHINGTON UNIVERSITY
COLUMBIAN SCHOOL OF ARTS AND SCIENCES
Department of Economics

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TOMP 206
M 19:10 – 21:00
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Economics of Technological Change and Innovation

Introduction

This course provides an overview of important issues related to technological change that have attracted the attention of economists up to the present time. Among all social sciences, economics may be argued to have taken the longest and broadest interest in technological advancement and innovation. The specific assumptions and methodologies of mainstream economic analysis have, however, been vigorously criticized more recently for failing to deal with the sources of technological advance. Criticism has basically coalesced on two fronts. First, it is argued that mainstream economics has not paid adequate attention to the institutional setup supporting innovation and economic growth. Second, it is argued that an overly mechanistic approach has failed to take into account the evolutionary processes involved in scientific and technological advancement. This course attempts to provide a balanced view, taking into account both mainstream and neo-institutional/evolutionary approaches as well as expanding to the appraisal of the sources of new technology.

The learning objective of the course is to assess the economic concepts regarding:

- (a) the origins of new technology and its market introduction (innovation);
- (b) the process of technological advancement and differences between sectors;
- (c) the dissemination of innovations within and across firms, industries, and countries;
- (d) the impacts – economic benefits and costs – of innovation on individual organizations and on society at large;
- (e) policy concerns.

The course makes extensive use of case study material to underline the differences between technologies, industries, and organizations involved in scientific and technological advance, including companies, universities, and government agencies. The discussion flags the currently “hot” topics of research internationally and assists in the delineation of topics for further in-depth research by the students.

Course Requirements

The final grade for the course will be a weighed average of your grades on a term paper, a group presentation and in-class participation, and a take-home final examination. The term paper will account for 50%, in-class participation/presentation for 20%, and the final examination for the remaining 30% of the grade.

- i. *Term paper.* Work individually. Within certain parameters, you will choose a topic that best suits your research interests. You can take a theoretical approach, an empirical approach, a policy approach, or any combination of these. In case that you choose to create a case study of technological development (products or processes), you must try to apply some of the concepts discussed in class. It is advisable that you choose your topic as soon as possible and communicate with me before you start.

An approach that has worked well in the past for several course participants has been to critically survey the literature on particular subjects. Such surveys must consult much broader literature than present in our syllabus and synthesize it in a creative way. Examples of possible area topics are listed at the end of this syllabus. You are, however, free to venture outside this list.

Deadline for term papers: class meeting December 4.

- ii. *In-class participation.* This refers to:

(a) A student's general standing in class. You are expected to read regularly the assigned material before a lecture and participate in the general discussion during the lecture.

(b) The class meeting of October 23 will be devoted to short presentations and discussion. Class participants will be divided into small teams, each responsible for a short presentation (30') on a pre-assigned sector. The purpose of the presentation will be to summarize the evolution of technological advancement in the respective sectors and the identification of important issues that would be of interest to economists dealing with systems of sectoral innovation.

Team coalitions should emerge through self-selection. Presentation teams will be finalized during the third class meeting.

- iii. *Final examination.* The questions for the take-home final examination will be distributed during the class meeting of December 4. Answers will be due a week later.

Out of Class and Independent Learning Expected per Week

For this 3-credit graduate class students are expected to spend at least 350 minutes per week outside the classroom on preparation and class assignments.

Class Policies

Class attendance is expected. There will be no allowance for late work, except by prior arrangement with the instructor. Arrangements for make-up work must be made with the instructor. The instructor has the discretion to grant or refuse requests for late work or make-up work. Students are always welcome to discuss grades with the Professor. However, students wishing to formally contest a grade are required to write a memo outlining their case, along with supporting examples from the submitted assignment.

University Policies & Services

Academic Integrity Code. Academic dishonesty is defined as cheating of any kind, including misrepresenting one's own work, taking credit for the work of others without crediting them and without appropriate authorization, and the fabrication of information. For details and complete code, see: studentconduct.gwu.edu/code-academic-integrity

Sharing of Course Content. Unauthorized downloading, distributing, or sharing of any part of a recorded lecture or course materials, as well as using provided information for purposes other than the student's own learning may be deemed a violation of GW's Student Conduct Code.

Use of Student Work (FERPA). The professor will use academic work that you complete during this semester for educational purposes in this course during this semester. Your registration and continued enrollment constitute your consent.

Accommodations for Students with Disabilities. Any student who may need an accommodation based on the potential impact of a disability should contact the Disability Support Services office at 202-994-8250 in the Rome Hall, Suite 102, to establish eligibility and to coordinate reasonable accommodations. For additional information see: disabilitysupport.gwu.edu/

Religious Observances. In accordance with University policy, students should notify faculty during the first week of the semester of their intention to be absent from class on their day(s) of religious observance. For details and policy, see: students.gwu.edu/accommodations-religious-holidays.

Mental Health Services 202-994-5300. The University's Mental Health Services offers 24/7 assistance and referral to address students' personal, social, career, and study skills problems. Services for students include: crisis and emergency mental health consultations confidential assessment, counseling services (individual and small group), and referrals. For additional information see: counselingcenter.gwu.edu/

GW Security and Safety Policy. In the case of an emergency, if at all possible, the class should shelter in place. If the building that the class is in is affected, follow the evacuation procedures for the building. After evacuation, seek shelter at a predetermined rendezvous location.

Readings

Two books you should consider for the course:

Christine Greenhalgh and Mark Rogers (eds) (2010) Innovation, Intellectual Property and Economic Growth, Princeton University Press. [General purpose]

Linquiti, Peter D. (2015) The Public Sector R&D Enterprise: A New Approach to Portfolio Valuation, Palgrave Macmillan. [Specialized]

Students are advised to purchase at least the first of these two textbooks. They should be available at the University bookstore. Check out electronic form availability. They can also be accessed at Amazon and elsewhere.

These books, however, do not cover large parts of the course. Thus, the list of readings is supplemented by a significant number of articles from academic journals and chapters from other books and reports, referenced in detail in the following section.

An asterisk () denotes required reading material. No asterisk means recommended reading material.*

The instructor will provide access to all other required reading material (book chapters and articles) and a significant part of the supplementary, recommended material through Blackboard.

Several other edited books and monographs offer excellent supplementary sources of information for various sections of the course:

1. Bronwyn H. Hall and Nathan Rosenberg (eds) (2010) Handbook of the Economics of Innovation, Volumes I and II, Elsevier. [Electronic form available from GW Bookstore]
2. Albert O. Link and Nicholas S. Vonortas (eds) (2013) Handbook on the Theory and Practice of Program Evaluation, Edward Elgar Publishers.
3. Keun Lee (2013) Schumpeterian Analysis of Economic Catch-up, Cambridge University Press.
4. Faiz Gallouj and Faridah Djellal (eds.) (2010) The Handbook of Innovation and Services, Edward Elgar.
5. Jan Fagerberg, David C. Mowery and Richard R. Nelson (eds.) (2005) The Oxford Handbook of Innovation, Oxford University Press.

6. Chris Freeman and Luc Soete (1997) The Economics of Industrial Innovation, 3rd ed., The MIT Press.
7. Franco Malerba and Nicholas S. Vonortas (eds.) (2009) Innovation Networks in Industries, Edward Elgar.
8. Gerhard Rosegger (1996) The Economics of Production and Innovation, 3rd ed., Butterworth-Heinemann
9. Hal Varian, Joseph Farrell, and Carl Shapiro (2004) The Economics of Information Technology, Cambridge University Press.
10. Gregory Tassef (2007) The Technology Imperative, Edward Elgar

Schedule of Meetings and Readings

8/28

I. INTRODUCTION

A. Science, Technology and Innovation in Economic Analysis

- * Greenhalgh, Christine and Mark Rogers (eds) (2010) Innovation, Intellectual Property and Economic Growth, Princeton University Press.
[Ch 1]
[1] “The Nature and Importance of Innovation”
- * Freeman, Chris and Luc Soete (1997) The Economics of Industrial Innovation, 3rd ed., The MIT Press. [Ch 1]
[1] “Introduction”

II. THE NATURE OF INVENTION AND INNOVATION

9/11

A. Allocation of Research Resources

- * National Science Board Science and Engineering Indicators 2016, National Science Foundation [Chs: 4, 6].
[4] “R&D: National Trends and International Comparisons”
[6] “Industry, Technology, and the Global Marketplace”
<http://www.nsf.gov/statistics/2016/nsb20161/#/report>
- * Arrow, Kenneth (1962) "Economic welfare and the allocation of resources for invention," in Richard R. Nelson (ed.) The Rate and Direction of Inventive Activity, Princeton University Press.
- * Nelson, Richard R. (1959) "The simple economics of basic scientific research," Journal of Political Economy, June: 297-306.

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B. Agents and Process of Technological Advancement

- * Tasse, Gregory (2007) The Technology Imperative, Edward Elgar [Ch 7]
[7] “The Technology Life Cycle”
- * Greenhalgh, Christine and Mark Rogers (eds) (2010) Innovation, Intellectual Property and Economic Growth, Princeton University Press.
[Ch 2]
[2] “The Nature and Role of Intellectual Property”

- Hall, Bronwyn H. and Nathan Rosenberg (eds) (2010) Handbook of the Economics of Innovation, Elsevier. [Chs 5, 6, 8]
 [5] Stephan, Paula E. “The Economics of Science”
 [6] Foray, Dominique and Francesco Lissoni “University Research and Public-Private Interaction”
 [8] Feldman, Maryann P. “Stylized Facts in the Geography of Innovation”

III. MICROECONOMICS OF TECHNOLOGICAL CHANGE & INNOVATION

- 9/25 *A. Innovation, Firm and Market Characteristics, Scale and Scope in R&D*
- * Kamien, Morton I. and Nancy L. Schwartz (1982) Market Structure and Innovation, Cambridge University Press. [Chs 2, 3]
 [2] “Schumpeterian Hypotheses”
 [3] “Empirical Studies of the Schumpeterian Hypotheses”
 - * Hall, Bronwyn H. and Nathan Rosenberg (eds) (2010) Handbook of the Economics of Innovation, Elsevier. [Ch 4]
 [4] Cohen, Wesley M. “Fifty Years of Empirical Studies of Innovative Activity and Performance”
 - * Vonortas, Nicholas S. (2009) “Scale and Scope in Research”, in Henri Delanghe, Ugur Muldur, and Luc Soete (eds) European Science and Technology Policy, Edward Elgar.
 - * Greenhalgh, Christine and Mark Rogers (eds) (2010) Innovation, Intellectual Property and Economic Growth, Princeton University Press.
 [Ch 5]
 [5] “Innovative Firms and Markets”
- Rosegger, Gerhard (1996) The Economics of Production and Innovation, 3rd ed., Butterworth-Heinemann. [Chs 3, 4]
 [3] “The Microeconomics of Production and Technological Change”
 [4] “Returns to Scale, Economies of Scale, Economies of Scope, and Learning”
- 10/2 *B. Firm Strategy, Technology Markets, Collaborative Networks*
- * Freeman, Chris and Luc Soete (1997) The Economics of Industrial Innovation, 3rd ed., The MIT Press. [Ch 11]
 [11] “Innovation and Strategy of the Firm”
 - * Hall, Bronwyn H. and Nathan Rosenberg (eds) (2010) Handbook of the Economics of Innovation, Elsevier. [Ch 15]

[15] Arora, Ashish and Alfonso Gambardella “The Market for Technology”

- * Vonortas, Nicholas S. (2009) “Innovation Networks in Industry”, in Franco Malerba and Nicholas S. Vonortas (eds), Innovation Networks in Industries, Cheltenham, UK: Edward Elgar.
- * Vonortas, Nicholas S. (forthcoming) “Research and Technology Partnerships”, in Albert N. Link and Nicholas S. Vonortas Research Collaboration, Springer.

10/9 *Fall Break*

10/16 *C. Technology Dissemination*

- * Hall, Bronwyn H. and Nathan Rosenberg (eds) (2010) Handbook of the Economics of Innovation, Elsevier. [Chs 17, 18]
[17] Stoneman, Paul and Giuliana Battisti “The Diffusion of New Technologies”
[18] Bresnahan, Timothy “General Purpose Technologies”
- * Fagerberg, Jan, David C. Mowery and Richard R. Nelson (eds.) (2005) The Oxford Handbook of Innovation, Oxford University Press. [Ch 17]
[17] Hall, Bronwyn H. “Innovation and Diffusion”
- * Greenhalgh, Christine and Mark Rogers (eds) (2010) Innovation, Intellectual Property and Economic Growth, Princeton University Press.
[Ch 7]
[7] “Diffusion and Social Returns”

Rosenberg, Nathan (1976) "Factors affecting the diffusion of technology," in Perspectives on Technology, Cambridge University Press.

10/23 *D. Sectoral Systems of Innovation*

- * Malerba, Franco (2004) “Sectoral Systems of Innovation: Basic Concepts”, in F. Malerba (ed.) Sectoral Systems of Innovation, Cambridge University Press.

Manufacturing / Services

- * Hall, Bronwyn H. and Nathan Rosenberg (eds) (2010) Handbook of the Economics of Innovation, Elsevier. [Chs 11, 12, 22]

[11] Greenstein, Shane “Innovative Conduct in Computing and Internet Markets”

[12] F. M. Scherer “Pharmaceutical Innovation”

[22] Pardey, Philip G., Julian M. Alston and Vernon W. Ruttan “The Economics of Innovation and Technical Change in Agriculture”

* Fagerberg, Jan, David C. Mowery and Richard R. Nelson (eds.) (2005) The Oxford Handbook of Innovation, Oxford University Press. [Ch 16]
[16] Miles, Ian “Innovation in Services”

* Tassef, Gregory (2014) “Competing in Advanced Manufacturing: The Need for Improved Growth Models and Policies”, Journal of Economic Perspectives, 28(1): 27-48.

Additional readings to be provided by the presenting teams

IV. MACROECONOMICS OF TECHNOLOGICAL CHANGE & INNOVATION

^{10/30} A. Technology, Economic Growth, Jobs

* Fagerberg, Jan, David C. Mowery and Richard R. Nelson (eds.) (2005) The Oxford Handbook of Innovation, Oxford University Press. [Ch 18]
[18] Verspagen, Bart “Innovation and Economic Growth”

* Greenhalgh, Christine and Mark Rogers (eds) (2010) Innovation, Intellectual Property and Economic Growth, Princeton University Press.
[Chs 8, 10]
[8] “Models of Economic Growth”
[10] “Technology, Wages and Jobs”

* Hall, Bronwyn H. and Nathan Rosenberg (eds) (2010) Handbook of the Economics of Innovation, Elsevier. [Ch 20]
[20] Fagerberg, Jan, Martin Schrolek and Bart Verspagen “Innovation and Economic Development”

11/06 B. Productivity, Economic Convergence

* Organization for Economic Cooperation and Development (2016) OECD Compendium of Productivity Indicators, Paris: OECD. [Chs 1-3]
[1] Measuring Productivity
[2] Economic Growth and Productivity
[3] Productivity by Industry

* Barro, Robert J. (2016) “Economic Growth and Convergence, Applied Especially to China”, NBER Working Paper 21872, National Bureau of Economic Research, January.

Congressional Budget Office (2005) “R&D and Productivity Growth”, Background Paper.

Khan, Mosahid, Kul B. Luintel, and Konstantinos Theodoridis (2010) “How Robust is the R&D-Productivity Relationship? Evidence from OECD Countries”, Working Paper #1, December, WIPO.

Acemoglu, Daron, Philippe Aghion and Fabrizio Zilibotti (2003) “Vertical Integration and Distance to Frontier”, *Journal of the European Economic Association*, 1(2-3): 630-638.

11/13 *C. Technology and Economic Catch-up / Middle-Income Trap*

- * Larson, Greg, Norman Loayza and Michael Woolcock (2016) “The Middle-Income Trap: Myth or Reality?”, *Research Policy Briefs*, World Bank Group, No. 1, March.
- * Agenor, Pierre-Richard (2016) “Caught in the Middle? The Economics of Middle-Income Traps”, Working Paper #142, Fondation Pour Les Etudes et Recherches sur le Developpement International, May.
- * Radosevic, Slavo and Esin Yoruk (2016) “Why Do We Need a Theory and Metrics of Technology Upgrading?”, *Asian Journal of Technology Innovation*, DOI 10.1080/19761597.2016.1207415
- * Lee, Keun and Franco Malerba (2017) “Catch-Up Cycles and Changes in Industrial Leadership: Windows of Opportunity and Responses of Firms and Countries in the Evolution of Sectoral Systems”, *Research Policy*, 46: 338-351.

11/20 *D. International Aspects, Trade*

- * Greenhalgh, Christine and Mark Rogers (eds) (2010) *Innovation, Intellectual Property and Economic Growth*, Princeton University Press. [Ch 9]
[9] “Innovation and Globalization”
- * Organization for Economic Cooperation and Development (2016) *OECD Compendium of Productivity Indicators*, Paris: OECD. [Ch 4]
[4] “Productivity, Trade and International Competitiveness”
- * Fagerberg, Jan, David C. Mowery and Richard R. Nelson (eds.) (2005) *The Oxford Handbook of Innovation*, Oxford University Press. [Ch 12]
[12] Narula, Rajnesh and Antonello Zanfei “Globalization of Innovation: The Role of Multinational Enterprises”

11/27 *VII. PRIVATE AND SOCIAL RETURNS TO R&D*

A. Measuring the Returns to R&D

- * Hall, Bronwyn H. and Nathan Rosenberg (eds) (2010) Handbook of the Economics of Innovation, Elsevier. [Chs 23, 24, 26]
[23] Hulten, Charles R. “Growth Accounting”
[24] Hall, Bronwyn H., Jacques Mairesse and Pierre Mohnen “Measuring the Returns to R&D”
[26] Mairesse, Jacques and Pierre Mohnen “Using Innovation Surveys for Econometric Analysis”

Fagerberg, Jan, David C. Mowery and Richard R. Nelson (eds.) (2005) The Oxford Handbook of Innovation, Oxford University Press. [Ch 6]
[6] Smith, Keith “Measuring Innovation”

Several chapters of the book by Albert O. Link and Nicholas S. Vonortas (2013) are relevant.

12/04 *B. Risk in Future R&D Investments*

- * Linquti, Peter D. (2015) The Public Sector R&D Enterprise: A New Approach to Portfolio Valuation, Palgrave Macmillan. [Chs 3, 4]
[3] R&D Portfolio Valuation and Formation
[4] Public Sector R&D Valuation: A Practical Example

Vonortas, Nicholas S. and Chintal Desai (2007) “Real Options Framework to Assess Public Research Investments”, Science and Public Policy, 34(10): 699-708.

Term Paper Deadline

^12/11 *XIII. POLICY*

- * Tasse, Gregory (2007) The Technology Imperative, Edward Elgar [Ch 10]
[10] “Elements of STI Policy”
- * Greenhalgh, Christine and Mark Rogers (eds) (2010) Innovation, Intellectual Property and Economic Growth, Princeton University Press. [Chs 11, 12]
[11] “Microeconomic Policies to Promote Firm-Level Innovation”
[12] “Macroeconomic Issues and Policy”

- * Varian, Hal, Joseph Farrell, and Carl Shapiro (2004) The Economics of Information Technology, Cambridge University Press.

Bonvillian, William B. (2017) “Advanced Manufacturing: A New Policy Challenge”, *Annals of Science and Technology Policy*, 1(1): 1-131.

Final Examination Deadline

Note: Due to time limitations, the material on this syllabus does not cover comprehensively either all topics of interest to economists in the study of technological change and innovation or the available readings in each covered topic. For example, there is relatively little here on the formal industrial organization approach to R&D and technological innovation, or on technology and the environment, or on technology and employment. Students are very welcome to consult additional sources to cover various sections of the course, and strongly encouraged to do so in writing their term papers.

Possible Topic Areas for Survey Papers

1. Markets for Technology

Reasons for failure and remedies – appropriability, spillovers (different kinds of) – technological opportunity – modern concepts of knowledge and technological knowledge communication (systems of innovation, networks).

2. Theory of the Firm

Transaction costs – asset specificity – ownership – incomplete contracts for technology and opportunistic behavior – the boundaries of the firm: markets, hierarchies, and alternative (intermediate) organizational forms for promoting technological change and innovation.

3. Neo-Schumpeterian Hypotheses

Schumpeter and his early followers – firm size and innovation – industry concentration and innovation – long stream of empirical evidence.

4. Industrial Expenditures on Research and Development

Tournament models of R&D – non-tournament models of R&D – asymmetric models – uncertainty and factor indivisibilities – technology option models.

5. Returns to R&D: Private and Social

R&D and productivity: empirical results and measurement issues – alternative research paradigms, including the production function model at the firm and industry levels – private returns – social returns – various kinds of knowledge and the size of the gap between private and social returns.

6. Technological Change and Industry Entry and Exit

Entry and exit models – the role of small firms in innovation – industry evolution through time – technological change and industry evolution.

7. Industry Concentration

Effect on the rate of technological advance – mergers – acquisitions – joint ventures – strategic alliances, definitions and structures – concentration measures – antitrust concerns – evolution of antitrust legislation in the US and the EU.

8. Intellectual Property Rights: Appropriating Knowledge

The special role of IPRs in inducing innovation – various means for appropriating technological knowledge – the economics of the patent system – industry and regional differences – empirical results and case studies.

9. Technology Diffusion

The diffusion process – contagion and the diffusion curve – the logistic and other theoretic models – factors influencing diffusion – estimation – firm and industry case studies.

10. Measurement of Technology and Innovation

Input indicators – output indicators – technology indicators – innovation indicators and two Oslo (OECD) manuals – historical evolution of indicator formation and links to theoretical developments – usefulness for research.

11. International Considerations, Technology Transfer

Multinational corporations (MNCs): theory and evidence – MNCs and technological advance in home countries – MNCs and technological advance in host countries – technology and international trade: main theoretical views and empirical evidence.