

**THE GEORGE WASHINGTON UNIVERSITY**  
CCAS / ESIA

Department of Economics / Institute for International Science and Technology Policy

ECON 6255.80 / IAFF 6158.80  
1957 E, B14  
M 19:10 – 21:00  
Fall 2024

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## **Economics of Technological Change and Innovation**

**Note: This course will be delivered in-person with online accommodations (permission required)**

### **Introduction**

This course provides an overview of important issues related to technological change and innovation 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 advancement. 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 weighted 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 40%, in-class participation and group presentation for 30%, 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. If you do not have a topic, the instructor will give you one. 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 to the case some of the concepts developed in the course. It is advisable that you choose your topic as soon as possible and communicate with me before you start. You need to submit an outline of the intended term paper by **September 16**.

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: **December 2**.

- ii. **Class participation.** This refers to:
- (a) This portion of the grade is based on students' attendance, frequency and quality of participation in class discussion.
  - (b) The class meeting of **October 14** will be devoted to short presentations and discussion. Class participants will be divided into four teams at most, each responsible for a short presentation (20') on a pre-assigned sector followed by 10' Q&A. The purpose of the presentation will be to summarize the evolution of technological advancement in a sector and the identification of important issues that would be of interest to economists dealing with the innovation system of the sector in question.  
Team coalitions should emerge through self-selection. Presentation teams will be finalized during the third class meeting on **September 16**.
- iii. **Final examination.** The questions for the take-home final examination will be distributed on **December 2**. Answers will be due a week later (**December 9**).

## 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. There is, of course, no good way to estimate the time you spend on your significant term paper.

## Class Policies

Class attendance in person is expected. The course will be available online (Zoom) for people with emergency situations. There will be no allowance for late work on assignments, except by prior arrangement 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 instructor. 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. The use of AI software such as GPT4 to complete class assignments is prohibited. Such use will result in a failing grade as a gross violation of the academic integrity code.

## 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](http://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 Rome Hall, Suite 102, to establish eligibility and to coordinate reasonable accommodations. For additional information see: [disabilitysupport.gwu.edu/](http://disabilitysupport.gwu.edu/)

***Religious Observances.*** In accordance with University policy, students should notify faculty 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](http://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/](http://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**

There is no single good textbook to cover the multidimensionality of this course. The readings consist of articles from academic journals, book chapters, and reports, referenced in detail below.

The instructor will provide access to all required reading material and a significant part of the supplementary, recommended material through Blackboard.

## **Summary Schedule of Class Meetings**

8/26 INTRODUCTION: Science, Technology and Innovation in Economics

### I. THE NATURE OF INVENTION AND INNOVATION

9/9 A. Allocation of Research Resources

9/16 B. Agents and Process of Technological Advancement [**Deadline**]

### II. MICRO & MESO ANALYSIS OF TECHNOLOGICAL CHANGE / INNOVATION

9/23 A. Innovation, Firm and Market Characteristics, Scale and Scope in R&D

9/30 B. Firm Strategy, Technology Markets, Collaborative Networks

10/7 C. Technology Dissemination

10/14 D. Sectoral Systems of Innovation [**In-class presentations**]

10/21 E. Digital Economics / Economics of Artificial Intelligence / FinTech

### III. MACROECONOMICS OF TECHNOLOGICAL CHANGE & INNOVATION

10/28 A. Technology, Economic Growth, Productivity

11/4 B. Techno-economic Convergence / Catch-up / Middle-Income Trap

11/11 C. China's 40-Year Boom – How Sustainable?

11/18 D. International Aspects, Trade

### IV. EMPLOYMENT – POLICY

12/2 A. Automation and Jobs [**Deadline**]

12/9 B. Policy [**Deadline**]

## **Analytical Schedule of Class Meetings and Readings**

*Unmarked readings are required. An asterisk (\*) denotes recommended reading*

- 8/26            *INTRODUCTION: Science, Technology and Innovation in Economics*
- Greenhalgh, Christine and Mark Rogers (2010) *Innovation, Intellectual Property and Economic Growth*, Princeton University Press. [Ch 1]  
[Ch 1] “The Nature and Importance of Innovation”
- Freeman, Chris and Luc Soete (1997) *The Economics of Industrial Innovation*, 3<sup>rd</sup> ed., The MIT Press. [Ch 1]  
[Ch 1] “Introduction”
- I. THE NATURE OF INVENTION AND INNOVATION
- 9/9            *A. Allocation of Research Resources*
- National Science Board (2024) *The State of U.S. Science and Engineering 2024*, National Science Foundation.  
(1) “Discovery: U.S. and Global R&D”  
<https://ncses.nsf.gov/pubs/nsb20243/discovery-u-s-and-global-r-d>  
(2) “Translation: U.S. and Global Science, Technology, and Innovation Capabilities”  
<https://ncses.nsf.gov/pubs/nsb20243/translation-u-s-and-global-science-technology-and-innovation-capabilities>
- 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.
- \*            WIPO (2023) *The Global Innovation Index 2023: What is the Future of Innovation-Driven Growth*. Geneva. [Intro]  
[Intro] “GII 2023 at a Glance”, pp.17-23.
- 9/16            *B. Agents and Process of Technological Advancement*
- Schilling, Melissa A. (2020) *Strategic Management of Technological Innovation*, McGraw Hill. [Chs 2, 3]  
[Ch 2] “Sources of Innovation”  
[Ch 3] “Types and Patterns of Innovation”

- \* Tasse, Gregory (2007) *The Technology Imperative*, Edward Elgar. [Ch 7]  
[Ch 7] “The Technology Life Cycle”

**Deadline: Term Paper Outline / Team Formation for Oct. 17 Group Presentation**

*II. MICRO & MESO ANALYSIS OF TECHNOLOGICAL CHANGE / INNOVATION*

9/23 *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]  
[Ch 2] “Schumpeterian Hypotheses”  
[Ch 3] “Empirical Studies of the Schumpeterian Hypotheses”

Gilbert, Richard J. (2020) *Innovation Matters: Competition Policy for the High-Technology Economy*, The MIT Press, Cambridge, MA. [Chs 3, 6]  
[Ch 3] “Competition and Innovation Basics: Arrow versus Schumpeter”  
[Ch 6] “Competition and Innovation: Empirical Evidence”

Lamoreaux, Naomi R. (2019) “The Problem of Bigness: From Standard Oil to Google”, *Journal of Economic Perspectives*, 33(3): 94-117.

- \* Greenhalgh, Christine and Mark Rogers (2010), *op. cit.*, ch 5.  
[Ch 5] “Innovative Firms and Markets”

9/30 *B. Firm Strategy, Technology Markets, Collaborative Networks*

Schilling, Melissa A. (2020), *op. cit.* [Chs 4, 5]  
[Ch 4] “Standards Battles, Modularity, and Platform Competition”  
[Ch 5] “Timing of Entry”

Acker, Olaf, Florian Groene, and Germar Schroeder (2016) “The New Game of Global Tech”, *Strategy+Business*, PwC, 85: 1-15.

The Economist (2024) “Joint Adventures”, April 27.

- \* Bloom, Nicholas and John Van Reenen (2007) “Measuring and Explaining Management Practices Across Firms and Countries”, *Quarterly Journal of Economics*, CXXII(4): 1351-1408.

10/7 *C. Technology Dissemination*



Jan Fagerberg, David C. Mowery and Richard R. Nelson (eds) (2005) *The Oxford Handbook of Innovation*, Oxford University Press. [Ch 17]  
[Ch 17] Hall, Bronwyn H. “Innovation and Diffusion”

Bloom, Nicholas, Tarek Alexander Hasan, Aakash Kalyani, Josh Lerner, and Ahmed Tahoun (2021) “The Diffusion of Disruptive Technologies”, NBER Working Paper 28999.

Agrawal, Ajay K, Joshua S. Gans, and Avi Goldfarb (2023)  
“Similarities and Differences in the Adoption of General Purpose Technologies”, NBER Working Paper 30976.

10/14

*D. Sectoral Systems of Innovation (in-class presentations)*

Malerba, Franco (ed) (2004) *Sectoral Systems of Innovation*, Cambridge University Press. [Intro]  
[Intro] “Sectoral Systems of Innovation: Basic Concepts”

- \* West, Darrel M. (2019) *The Future of Work*, Washington, D.C.: Brookings. [Part 1]  
[Part 1] “Robots”, “Artificial Intelligence”, “The Internet of Things”
- \* Agrawal, Ajay, Joshua Gans, and Avi Goldfarb (eds) (2019) *The Economics of Artificial Intelligence*, NBER and The University of Chicago Press. [Ch 4]  
[Ch 4] Cockburn, Iain M., Rebecca Henderson, and Scott Stern “The Impact of Artificial Intelligence on Innovation”.
- \* The Economist (2023) “A Difficult New World: The Car Industry”, Special Report, April 22.
- \* Lakdawalla, Darius N. (2018) “Economics of the Pharmaceutical Industry”, *Journal of Economic Literature*, 56(2): 397-449.
- \* WIPO (2019) *The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation*. Geneva.
- \* De Rassenfosse, Gaetan, Dominique Foray et al. (2020) “COVID-19: Insights from Innovation Economists”, *Research Paper*, College of Management of technology, Ecole Polytechnique Federale de Lausanne.
- \* WIPO (2018) *The Global Innovation Index 2018: Energizing the World with Innovation*. Geneva.

- \* Storey, Chris, Pinar Cankurtaran, Paulina Papastathopoulou, and Erik Van Hultink (2015) “Success Factors for Service Innovation: A Meta-Analysis”, *Journal of Product Innovation Management*, 33(5): 527-548.
- \* Miles, Ian (2005) “Innovation in Services”, in Jan Fagerberg, David C. Mowery and Richard R. Nelson (eds.) (2005), *op. cit.*

**Asterisk readings are indicative: Additional to be provided by the presenting teams**

10/21

*E. Digital Economics / Economics of Artificial Intelligence / FinTech*

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

Goldfarb, Avi and Catherine Tucker (2019) “Digital Economics”, *Journal of Economic Literature*, 57(1): 3-43.

- \* World Economic Forum (2024) “The Future of Global Fintech: Towards Resilient and Inclusive Growth”, Insight Report, January 24.
- \* U.S. House of Representatives, Subcommittee on Antitrust, Commercial and Administrative Law (2020) “Investigation of Competition in Digital Markets”, Report.

### III. MACROECONOMICS OF TECHNOLOGICAL CHANGE & INNOVATION

10/28

*A. Technology, Economic Growth, Productivity*

Greenhalgh, Christine and Mark Rogers (2010), *op. cit.* [Ch 8]  
[Ch 8] “Models of Economic Growth”

Monthly Labor Review (2021) “The U.S. Productivity Slowdown: An Economy-wide and Industry-level Analysis”, April.

Manyika, James and Michael Spence (2023) “The Coming AI Economic Revolution: Can Artificial Intelligence Reverse the Productivity Slowdown?”, *Foreign Affairs*, 102(6): 70-86.

Agrawal, Ajay, Joshua Gans and Avi Goldfarb (eds) (2019), *op. cit.* [Ch 1]  
[Ch 1] Brynjolfsson, Erik, Daniel Rock, and Chad Syverson “Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics”

- \* Bloom, Nicholas, Charles I. Jones, John Van Reenen, Michael Webb (2020) “Are Ideas Getting Harder to Find?”, *American Economic Review*, 110(4): 1104-1144.

11/4

*B. Techno-economic Convergence / Catch-up / Middle-Income Trap*

Cicera, Xavier and William F. Maloney (2017) *The Innovation Paradox: Developing Country Capabilities and the Unrealized Promise of Technological Catch-Up*, Washington, D.C.: World Bank. [ES & Chs 1-3]

“Executive Summary”

[Ch 1] “The Innovation Paradox”

[Ch 2] “The Nature of Innovation in Developing Countries”

[Ch 3] “The Innovation Paradox and the National Innovation System”

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.

Naude, Wim “Sustainable Development: Is Entrepreneurship Falling Short of Expectations?”, 2022 Projekt Leonardo Lecture, Aachen University.

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Lee, Jeong-Dong, Keun Lee, Dirk Meissner, Slavo Radosevic, and Nicholas S. Vonortas (eds) (2021) *The Challenges of Technology and Economic Catch-up in Emerging Economies*, Oxford University Press.

[Chs 4, 5, 7, 10]

[Ch 4] Lee, Jeong-Dong, Chulwoo Baek, and Jung-In Yeon “Middle Innovation Trap: Capability Transition Failure and Stalled Economic Growth”

[Ch 5] Lee, Keun “Economics of Technological Leapfrogging”

[Ch 7] André Cherubini Alves, Nicholas S. Vonortas, and Paulo Antônio Zawislak “Macro and Micro Foundations for Technology Upgrading and Innovation: The Case of Shipbuilding and Offshore Industry in Brazil”

[Ch 10] Tilman Altenburg “Catching-up or Developing Differently? Techno-Institutional Learning with a Sustainable Planet in Mind”

11/11

*C. International Aspects, Trade*

United National Conference on Trade and Development (2024) *World Investment Report 2024*, New York: UNCTAD. [ES & Ch 1]

[ES] “Key” (pp.xiii-xix)

[Ch 1] “International Investment Trends” (pp.1-44)

The Economist (2024) “The New Economic Order”, “Globalization in Reverse”, Briefing, May 11.

The Economist (2023) “Homeland Economics”, Special Report, October 7

- \* World Bank (2020) *World Development Report: Trading for Development in the Age of Global Value Chains*, Washington, D.C.: World Bank Group.  
[ES & Chs 1-2]  
“Overview”  
[Ch 1] “The New Face of Trade”  
[Ch 2] “Drivers of Participation”

11/18 *D. Country Case I: China’s 40-Year Boom – How Sustainable?*

Pettis, Michael (2023) “China’s Economic Growth Model is Dying”,  
Online Interview (<https://www.youtube.com/watch?v=XO8o0TO-rfg>)

Posen, Adam S. (2023) “The End of China’s Economic Miracle”, *Foreign Affairs*, August 2.

Tooze, Adam (2023) “Wither China?”, *Chartbook* (online)  
[Part I] “Authoritarian Impasse?”  
[Part II] “Posen v. Pettis - Authoritarian Impasse v. Structural Dead-End”  
[Part III] “Policy Hubris and the End of Infallibility”

Wei, Lingling and Stella Yifan Xie (2023) “China’s 40-Year Boom is Over. What Comes Next?”, *Wall Street Journal*, August 20.

- \* Chan, Kyle (2024) “Third Plenum Industrial Policy: US-China Mirror Imaging”, July 25.

12/2 *E. Country Case II: India’s Economy*

The Economist (2024) “How Strong is India’s Economy?”, April 27, p.9.

The Economist (2024) “India’s Economy”, Special Report, April 27.

The Economist (2024) “Powering Up”, June 22, pp.61-62.

**Deadline:** *Term Paper Submission / Take-home Final Exam Distributed*

#### IV. POLICY

12/9

##### *B. The Future of Innovation-Driven Growth / Policy*

Rodrik, Dani, Reka Juhasz, and Nathan Lane (2023) “Economists Reconsider Industrial Policy”, Commentary, *Project Syndicate*, August 4.

Fagerberg, Jan (2016) “Innovation Policy: Rationales, Lessons, and Challenges”, *Journal of Economic Surveys*, pp. 1-17.

Bloom, Nicholas, John Van Reenen, and Heidi Williams (2019) “A Toolkit of Policies to Promote Innovation”, *Journal of Economic Perspectives*, 33(3): 163-184.

Shin, Rachel (2023) “The Chicago School Economist Who Warned Years Ago of America’s ‘Business Dynamism’ Fading Still Sees Something Broken in the Background”, *Fortune*, August 12.

Appelt, Silvia et al. (2023) “The Impact of R&D Tax Incentives: Results from the OECD microBeRD+ Project”, OECD STI Policy Papers, #159, October.

**Deadline:** *Final Examination Answers Submitted*

## **Examples Topic Areas for Survey Papers (indicative)**

### **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 and Employment**

Artificial intelligence, robotics, automation have raised important questions about the future of work.

### **10. 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.

### **11. 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.

### **12. 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.

### **13. Industry Studies**

Innovation across different industry sectors and subsectors such as information technology, robotics, pharmaceuticals, banking, agriculture etc. Role of technology platforms.

### **14. Technology, Energy, Environment**

Choose subsectors to analyze in depth. Fossil, nuclear, renewables.

### **Supplementary Reading (not part of the course)**

Several books offer excellent supplementary sources of information.

1. Keun Lee, Jeong-Dong Lee, Slavo Radosevic, Nicholas S. Vonortas and Dirk Meissner (eds) (2021) *The Challenges of Technology and Economic Catch-Up in Emerging Economies*, Oxford University Press.
2. Bronwyn H. Hall and Nathan Rosenberg (eds) (2010) *Handbook of the Economics of Innovation*, Volumes I and II, Elsevier.
3. Albert O. Link and Nicholas S. Vonortas (eds) (2013) *Handbook on the Theory and Practice of Program Evaluation*, Edward Elgar Publishers.
4. Keun Lee (2019) *The Art of Economic Catch-Up: Barriers, Detours and Economic Leapfrogging in Innovation Systems*, Cambridge University Press.
5. Ajay Agrawal, Joshua S. Gans and Avi Goldfarb (eds) (2019) *The Economics of Artificial Intelligence: An Agenda*, National Bureau of Economic Research.
6. Gustavo Crespi, Eduardo Fernandez-Arias and Ernesto Stein (eds) (2014) *Rethinking Productive Development: Sound Policies and Institutions for Economic Transformation*, Inter-American Development Bank.
7. Franco Malerba and Maureen McKelvey (2019) *Knowledge-Intensive Innovative Entrepreneurship*, NOW Press.
8. Faiz Gallouj and Faridah Djellal (eds.) (2010) *The Handbook of Innovation and Services*, Edward Elgar.
9. Jan Fagerberg, David C. Mowery and Richard R. Nelson (eds.) (2005) *The Oxford Handbook of Innovation*, Oxford University Press.
10. Chris Freeman and Luc Soete (1997) *The Economics of Industrial Innovation*, 3<sup>rd</sup> ed., The MIT Press.
11. Franco Malerba and Nicholas S. Vonortas (eds.) (2009) *Innovation Networks in Industries*, Edward Elgar.
12. Gerhard Rosegger (1996) *The Economics of Production and Innovation*, 3rd ed., Butterworth-Heinemann
13. Gregory Tassej (2007) *The Technology Imperative*, Edward Elgar.
14. Linquiti, Peter D. (2015) *The Public Sector R&D Enterprise: A New Approach to Portfolio Valuation*, Palgrave Macmillan.