DEPARTMENT OF ECONOMICS & MANAGEMENT

UNIVERSITÀ DEGLI STUDI DI FERRARA
- EX LABORE FRUCTUS -

The diffusion/adoption of innovation

Economics of Innovation

Ugo Rizzo

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Introduction

- Studies on demand and supply of innovations seeks to understand the factors associated with demand and consumption of innovation
- Diffusion of innovation across a market or an economy regards the understanding of the rate at which consumers take up an innovation
- The rate at which an innovation diffuses will depend on the factors that influence individual consumption decisions and the rate at which these change over time

Rosenberg, 1972

“New techniques exert their economic impact as a function of the rate at which they displace older techniques and the extent to which the new techniques are superior to the old ones. Although we are a still a very long way from being able to assess the exact role of technological change – as distinct from all other factors – in generating the rise in resource productivity which is at the heart of the growth process, it is, I think, clear that the contribution of technological change itself will have to be established through the study of diffusion. Only in this way can we develop a closer understanding of the rate at which new techniques, once invented, have been translated into events of economic significance.”

Hard prediction

- “I think there is a world market for maybe five computers” (Thomas Watson, president of IBM, 1943)
- “Television won't be able to hold on to any market it captures after the first six months. People will soon get tired of staring at a plywood box every night” (Darryl Zanuck, executive at 20th Century Fox, 1946)
- “Nuclear-powered vacuum cleaners will probably be a reality within ten years” (Alex Lewyt, president of Lewyt vacuum company, 1955)
- “Two years from now, spam will be solved” (Bill Gates, founder of Microsoft, 2004)

The challenge of diffusion

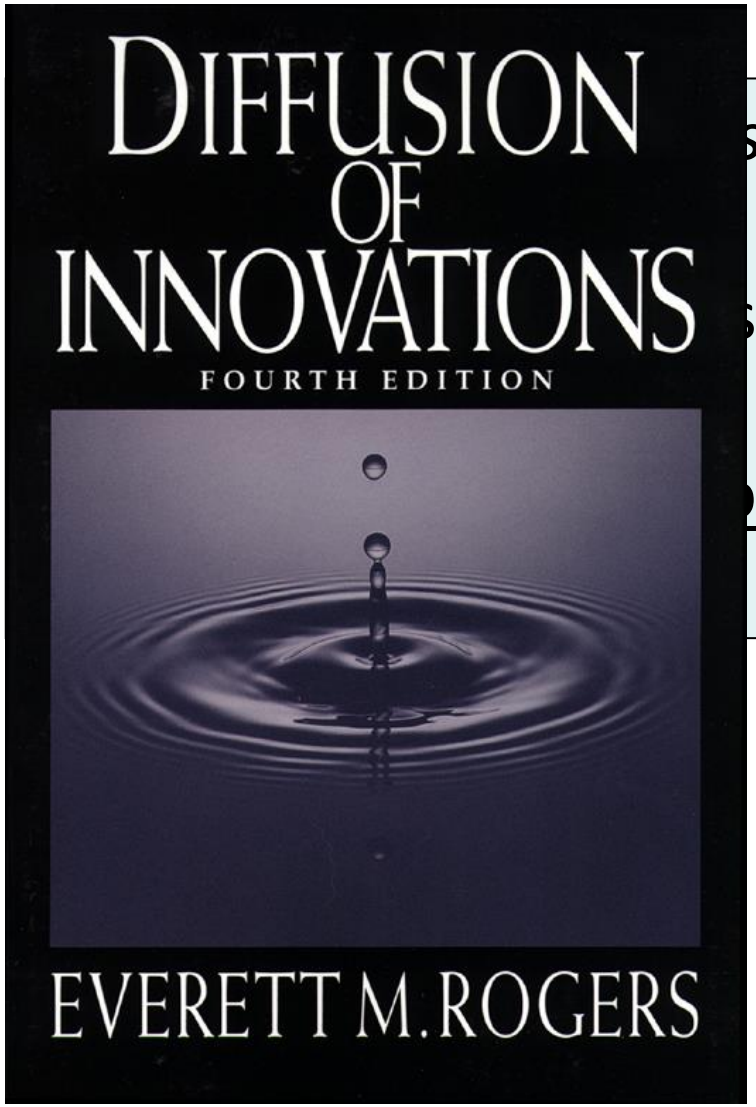
"Given one hundred different innovations conceived at the same time – innovations in the form of words, in mythological ideas, in industrial processes, etc. – ten will spread abroad while ninety will be forgotten" Gabriel Tarde, *The Laws of Imitation* (1903)

<u>What stops the spread of an invention / innovation?</u>
Costs too much, not very useful, something else works better, nobody knows about it, too risky, socially embarrassing etc..

Rosenberg, 1972, p. 6

"if one examines the history of many innovations, one cannot help being struck by two characteristics of the diffusion process: its apparent overall **slowness** on the one hand, and the wide **variations** in the rates of acceptance of different inventions, on the other"

Defining diffusion



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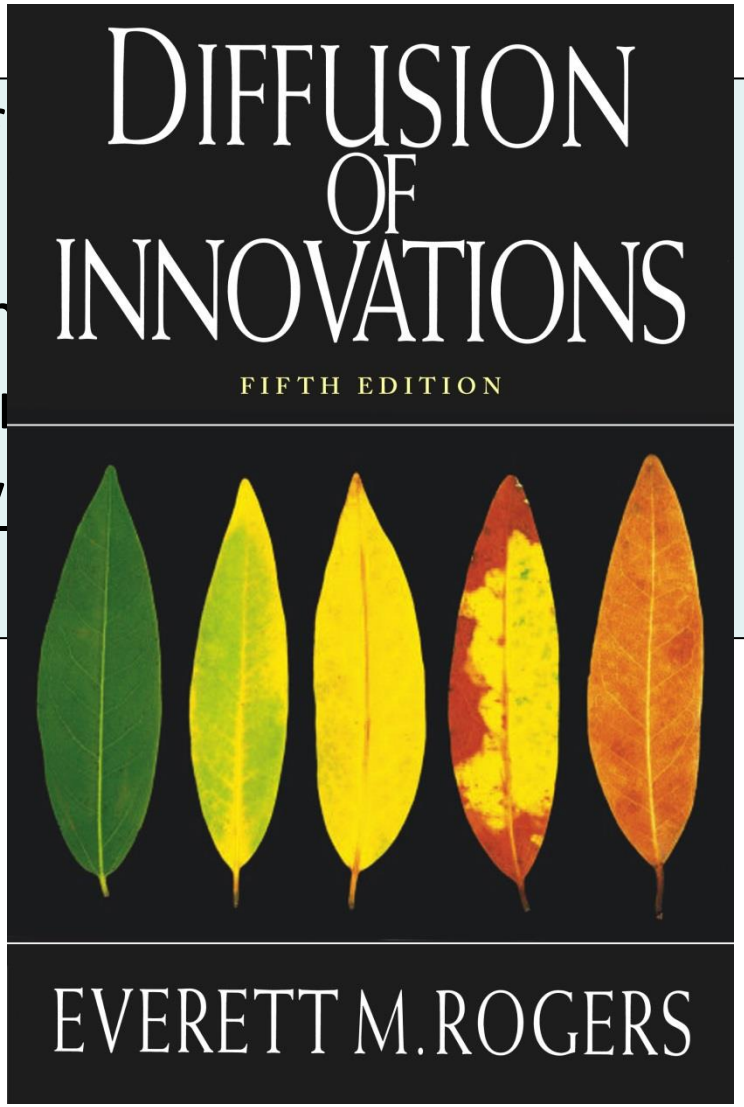
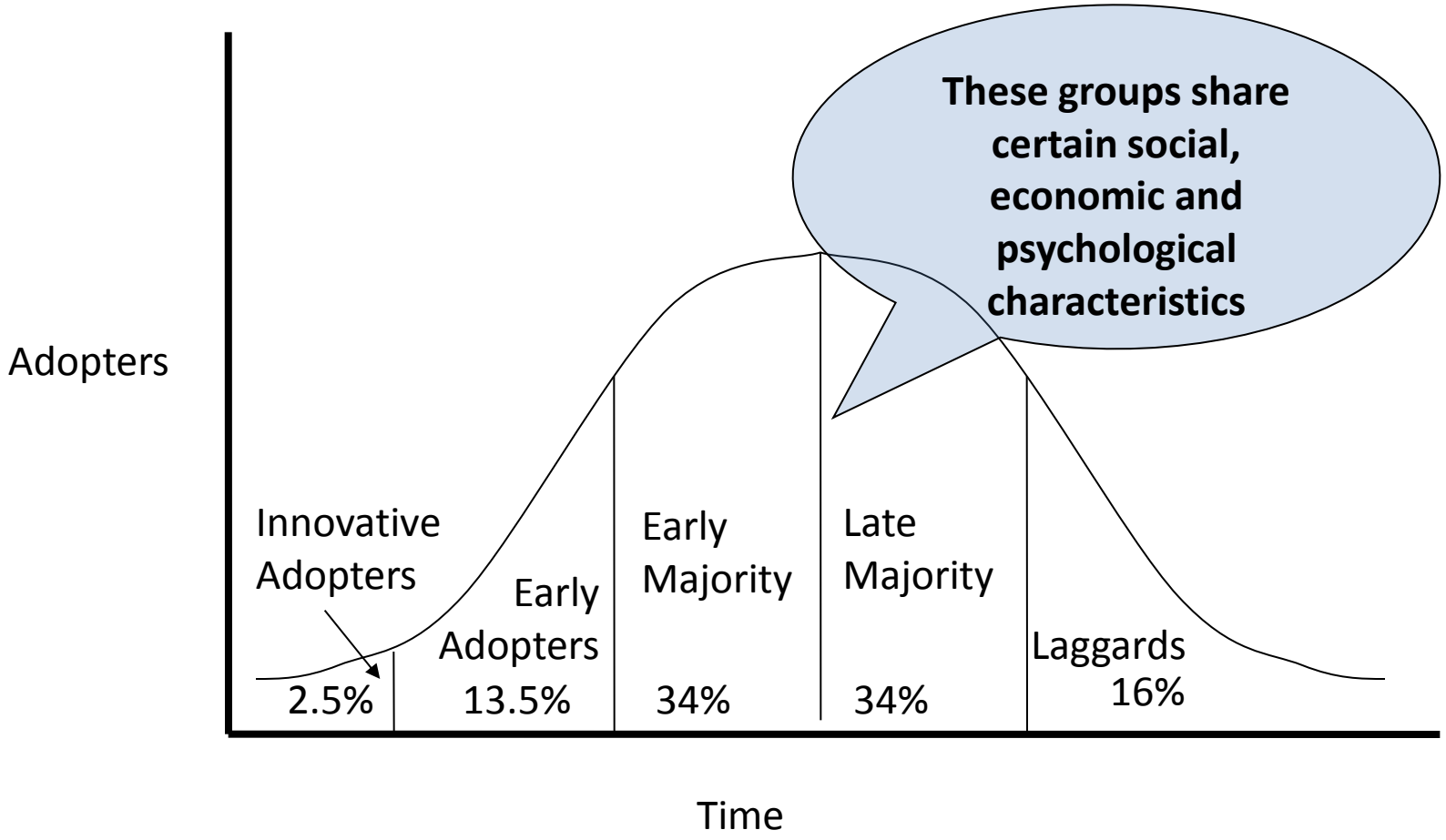


Time dimension: Categories of adopters



Slowness

- The role of subsequent improvements after the invention are often much more important than the invention itself in respect to the diffusion of the innovation
  - Enos (1968) distinguish “alpha phase” – cost reduction which occur when the new process is introduced à- and the beta phase – cost reduction flowing from the subsequent improvements in the new process:
  - “The evidence from the petroleum refining industry indicates that improving a process contributes even more to technological progress than does its initial development” (Enos, 1968, p. 180)

Slowness (2)

- “The transition to a new technique is often slowed by the extreme difficulty of breaking away from the old forms and embracing the different logic of a new technique or principle”
  - Rosenberg, 1972, referring to Marx:
- “To what an extent the old forms of the instruments of production influenced their new forms at first starting, is shown by, amongst other things, the most superficial comparison of the present power loom with the old one, of the modern blowing apparatus of a blast-furnace with the first inefficient mechanical reproduction of the ordinary bellows, and perhaps more strikingly than in any other way, by the attempts before the invention of the present locomotive, to construct a locomotive that actually had two feet, which after the fashion af a horse, it raised alternately from the ground. It is only after considerable development of the science of mechanics, and accumulated practical experience, that the form of a machine becomes settled entirely in accordance with mechanical principles, and emancipated from the traditional form of the tool that gave rise to it” (Karl Marx, Capital).

Slowness (3)

- Closely associated with the gradual improvement in the innovation itself is the development of the human skills upon which the use of the new technique depends in order to be effectively exploited. There is in other words a learning period, the length of which will depend upon many factors, including the complexity of the new techniques, the extent to which they are novel or rely on skills already available or transferable from other industries, etc.
- Since often it takes time to acquire the needed skills, it will also take time to establish the superior efficiency of a new technique over existing ones.
- For the one of you interested, “Rosenberg (1972), Factorsd affecting the diffusion of innovation” expand this point for the machine industry. Very good reading.

Complementarities

- A given invention, however promising, often cannot fulfill anything like its potential unless other inventions are made relaxing or bypassing constraints which would otherwise hamper its diffusion and expansion.
- A single technological breakthrough hardly ever constitutes a complete innovation. Before the productivity-increasing benefits of any single breakthrough can be realized, many other accommodations need to be made.
  - As an example bridge-building needed to adapt in materials, designs and structures to allow railroad networks development

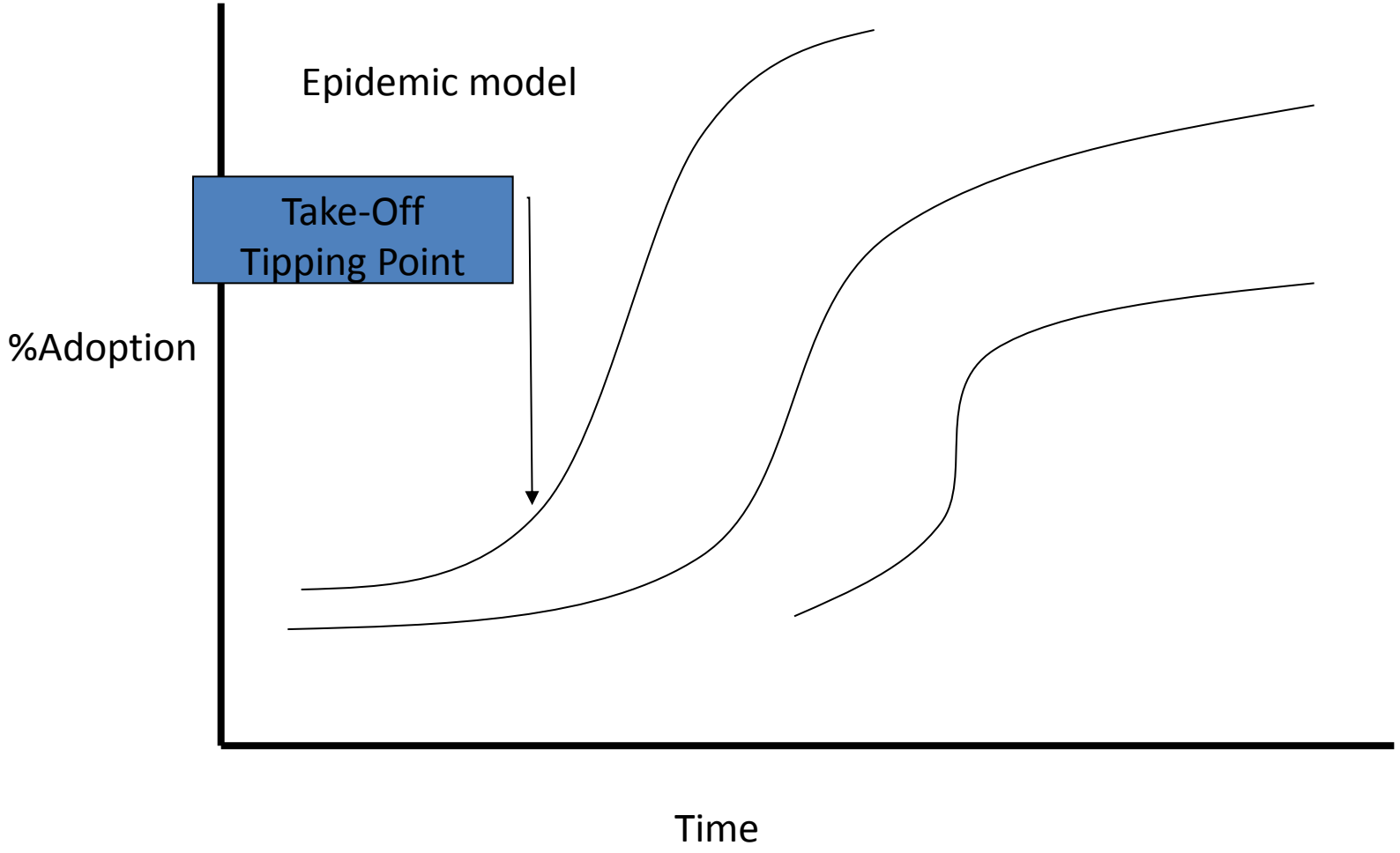
Epidemic model: the basic model

- There is a certain similarity between the diffusion of a new technology amongst population of users and the spread of an infectious disease amongst a population of people who do not have resistance
- Each time the consumer is exposed to the new product or service there is a certain probability that (s)he will be infected
- In its simple form it is assumed that adoption is proportional to the product between infected and uninfected

  New consumers= a(infected*uninfected)

Rate of adoption: the s-shaped curve

Different innovations display different patterns



Social System

- The social structure of the population of potential adopters
- “It is as unthinkable to study diffusion without some knowledge of the social structures in which potential adopters are located as it is to study blood circulation without adequate knowledge of the veins and arteries” (Katz, 1961)
- Social structure influences the operation of communication channels – e.g. bureaucratic organisation

Nelson et al. (2004)

- Adoption of innovation, studied putting in relation two characteristics that feature the innovation process: innovation efficacy and increasing returns
  - Efficacy: the adoption process for innovations that are easy to specify and can be replicated accurately differs from those that are somewhat amorphous and hence difficult to evaluate in a generally relevant way (role of direct/sharp feedback)
  - Increasing returns: extent to which the benefits of adoption are affected by the number of users who have previously adopted

Four models of innovation diffusion

(Nelson et al., 2004)

	Absence of dynamic increasing returns	Presence of dynamic increasing returns
Ability to get sharp, persuasive feedback	Model I Rational choice diffusion	Model 2: Quasi rational choice with possibility of lock-in
Inability to get sharp, persuasive feedback	Model 4 Fads	Model 3 Social construction

Model 1: Rational Choice

- Criteria of merit are sharp and unambiguous
- Objective learning from *ex ante* experimentation or evidence from actual use
- Previous use leads to dissemination of precise information about performance of the innovation
- Experts and their opinions influence the rate of adoption (but, not the extent)
- Rational choice model = most economic theory and technological historians

Model 2: Quasi rational choice with possibility of lock-in

- Differs from model one on a single regard:
  - The presence of 'dynamic increasing returns'
- The number of potential users who adopt the innovation affects its performance – e.g. more R&D or interoperability
- Transient historical events lead to lock-in because of network effects
- Paul David examples of QWERTY vs. DVORAK and AC vs. DC – relatively 'inefficient' innovations can get chosen at the outset.
  - Path dependency [David, 1985. Clio and the Economics of QWERTY. *The American Economic Review*, Vol. 75, No. 2, Papers and Proceedings, pp. 332-337]

Model 3: Social construction

- Differs from 1 & 2 because difficult to get sharp feedback on performance that all actors interpret similarly (interpretative flexibility) because:
  - Objective criteria leave considerable room for disagreement about details
  - Innovation is 'amorphous' – implementation differs from case to case
- Lock-in can occur in same way as model 2, but in this case it is through the repeated judgements of dominant social groups, rather than any objective criteria

Model 4: Fads

- Similar to model three in that there is an absence of strong objective criteria regarding performance.
- But different to model 3 because social constructivism does not create a bandwagon in this case, because
  - Broad force of opinion may be fickle
  - No sanctions on non-adopters

Hybrid corn – new agricultural technology

- Rapid uptake from late 1920s
- Initial assumption: profitable to adopt – better than previous technology
- 'Public' experimentation on yields
- Model 1 story?

Hybrid Corn – alternative explanations

- Farmers needed to adopt new farming practices as well as seeds – which improved yields?
- US DoA focus on hybrids and increasing population of adopters stimulated more R&D, leading to improved performance – **model 2**?
- Commercial interests – farmers need to buy hybrid seeds each year, rather than collecting their own with the 'open pollinating' varieties – more profit from hybrid seeds
  - **Model 3** story?

Exercise – Which model fits best and why?

- Organic food – final consumers
- GM food - farmers
- Mobile phones
- Skype
- Atkins diet
- Email
- Vitamin supplements / alternative medicine
- Microsoft Windows
- Focus groups

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