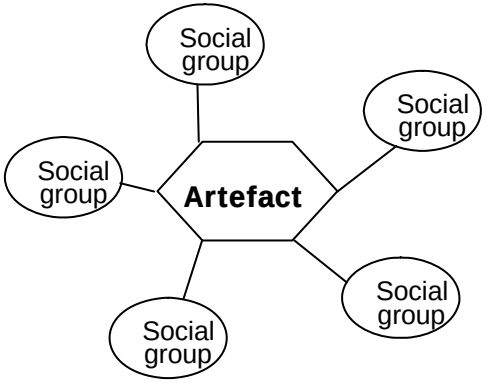
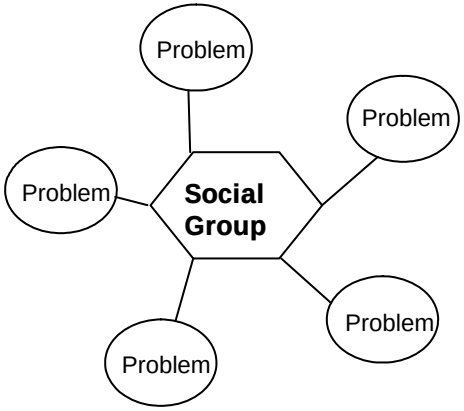
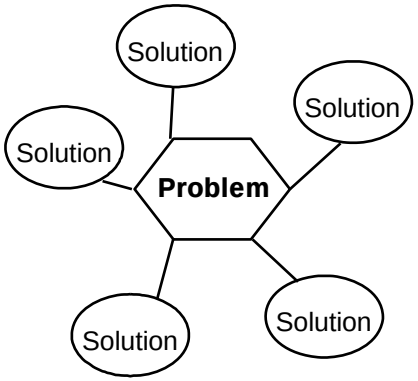
Technology Dynamics and Transition Management in China

Technology Dynamics: Concepts and Theories







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January 8, 2010

Technology Dynamics

Itaipu Dam

Background: development; “Brazil energy superpower”

Output: 93% Of the energy consumed by Paraguay and 20% of that consumed by Brazil (2005)

Context: negotiations and agreements between Brazil, Paraguay and Argentina

Problem: 2000-2001 Drought resulted in recurring blackouts and rationing of electricity usage

Social impact: approximately 10,000 families were dislodged from their plots. Some of these families eventually came to be members of one of Brazil's largest social movements : the Landless Workers Movement.

http://en.wikipedia.org/wiki/Image:Itaipu2.JPG

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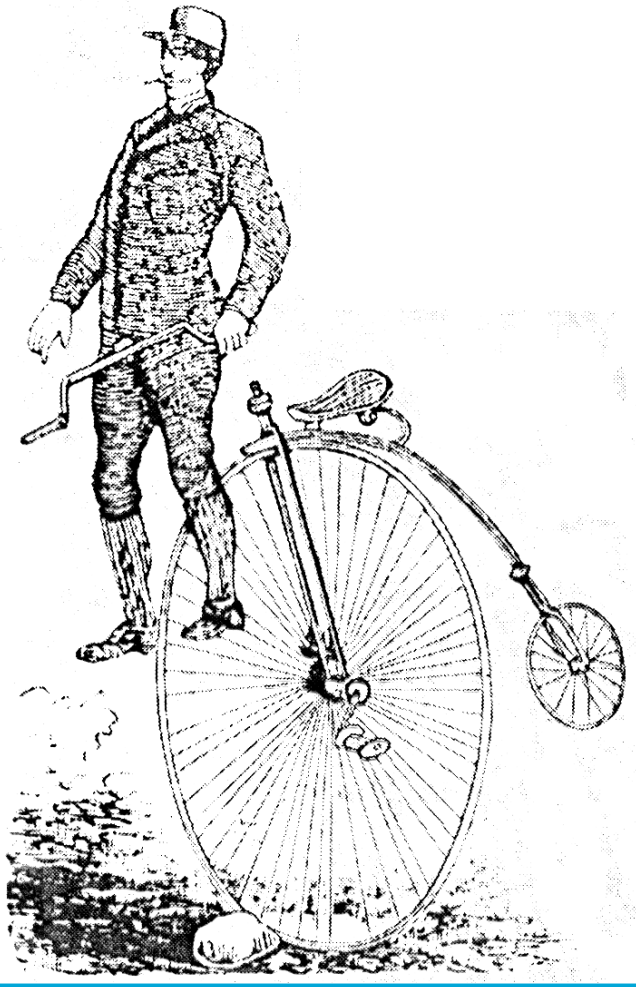
Technology Dynamics

What is happening here?



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Technology Dynamics

What is happening here?

Does technology* development take place autonomously or is technology shaped by its social context?

In other words: do engineers take the lead in technology development or do they have to do what society asks them to do?

* Technology = product, man-made artifact or technical system, hardware

Technology Dynamics

Visions

Technological determinism / Technology push:

- Technology determines society
- Technology is always a positive sum game
- Technology development is autonomous & linear

Social constructivism / society demands:

- Society and social groups determine technology; e.g. SCOT-model

Co-evolution of technology & society

- E.g. socio-technical systems theory (Hughes)

Technology Dynamics

Autonomous Technology

Every new generation has some creative geniuses. They invent some new technologies (by there more than average intelligence or by pure coincidence). The act of invention is independent of society. Succesful inventions diffuse in society and, thereupon, transform society.

Technology Dynamics

Autonomous Technology

Technology innovation is not accidental but depending on scientific progress. As scientific progress is the result of its own dynamics, and independent of societal change, technological change is independent of society.

(E.g. Dijksterhuis, 1950 and Koyre, 1943).

Technology Dynamics

Autonomous Technology

Scientific knowledge accumulates

Technology is applied science

Resources for technological innovation are growing forever

Technology is ever improving

Technological autonomy → Technological determinism

Jacques Ellul: Traditional technology vs. modern technology (1960s)

Technology Dynamics

Traditional Technology according to Ellul:

Limited in its application (technologies were often based on specific local resources and therefore hardly transferable);

Dependent on limited resources and on 'skill' (skills like making and repairing tools, but also being able to judge weather conditions, or the tides);

Local in its character, i.e., technological solutions for specific problems were embedded in local culture and traditions.

Technology Dynamics

Ellul characterizes modern technology by:

Automatism, i.e. there is only one 'best' way to solve a problem, and this technology seems to be compelling, everywhere on the planet;

Self increase, i.e. a new technology reinforces the growth of other technologies: this leads to exponential growth;

Indivisibility: the technological way of life must be accepted completely, including its good and bad sides;

Cohesion, i.e. technologies that are used in various different areas have much in common;

Universalism, i.e. technology is geographically as well as qualitatively omnipresent.

Unabomber Attacks

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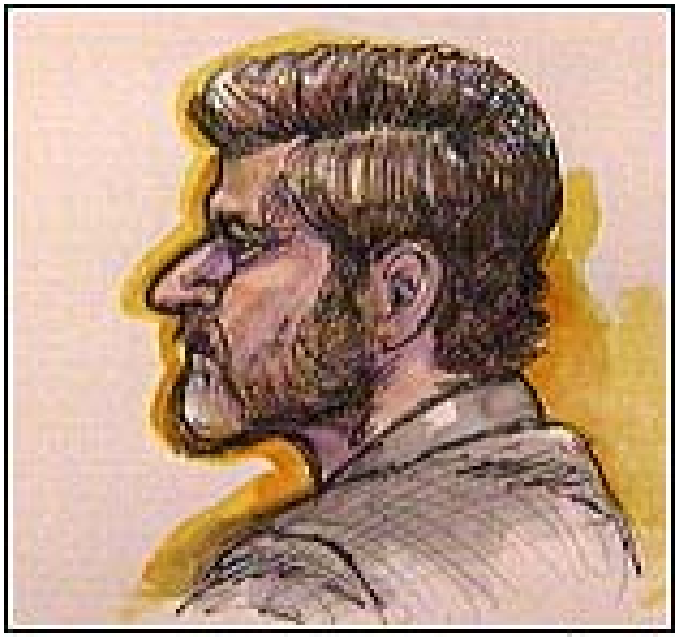
Unabomber Attacks

Unabomber Reasoning

The car increases our freedom by
    increased freedom of movement
By having a car, we can do our shopping
    in malls
Small neighbourhood shops disappear
We therefore are forced to have a car
So a technology like the car limits our
    liberty

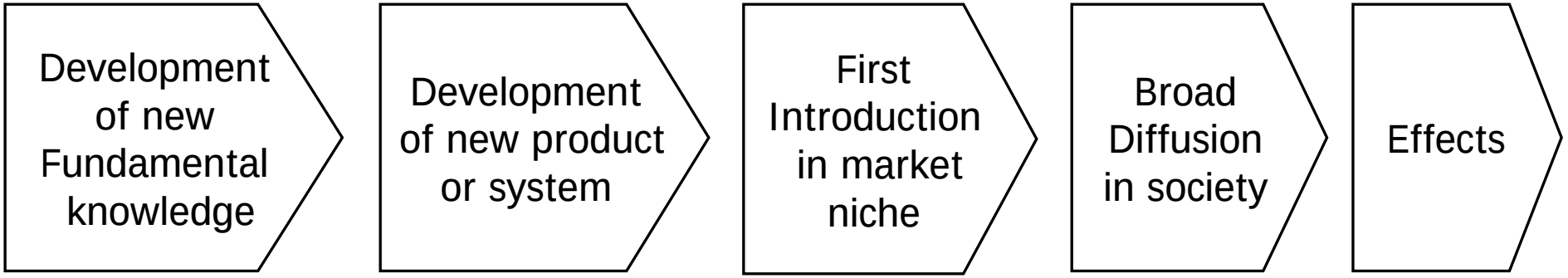
Implications of this view for possibility to
    steer technology development?



Kaczynski (CNN)

Technology Dynamics

The linear model of technology development



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Technology Dynamics

Social constructivism

Various social groups are involved with technology

Every group has a specific view of a certain technology

Example: PC.

- secretary: type writer
- book keeper: administration tool
- at home: communication tool

Technologies are shaped by demand / influence of relevant social groups

Technology Dynamics

SCOT-model: Social Construction of Technology

Artifact

Relevant social groups

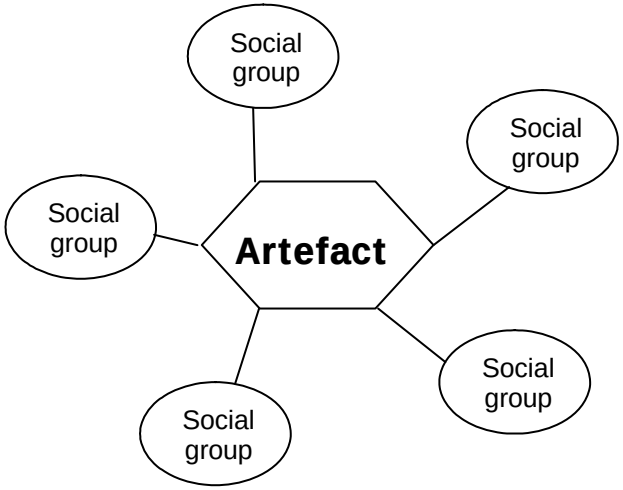
Interpretative flexibility

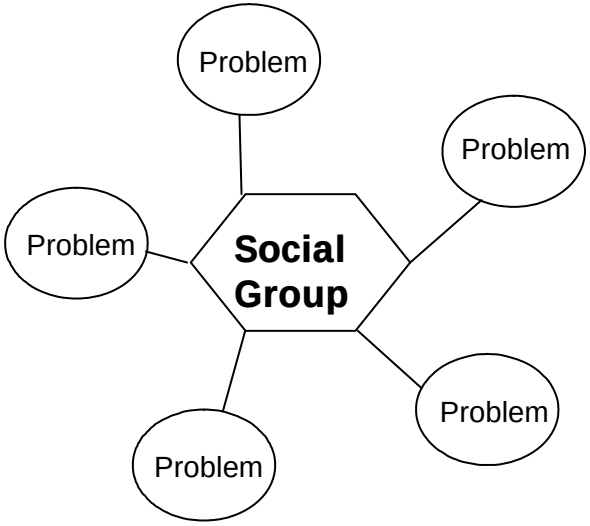
Inclusion of new groups

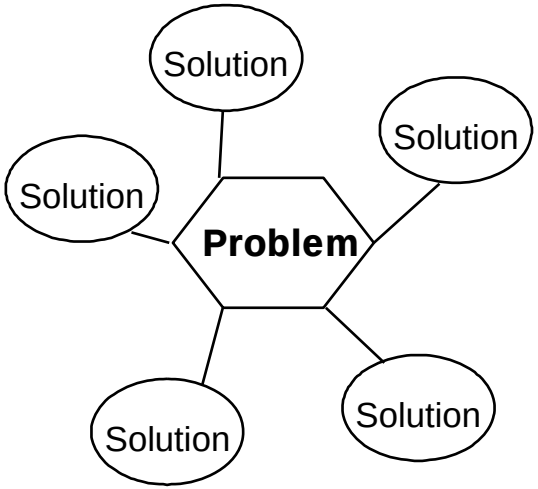
Technological frame

Technology Dynamics

SCOT-model: Social Construction of Technology







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Technology Dynamics

Example: Development of the Bicycle

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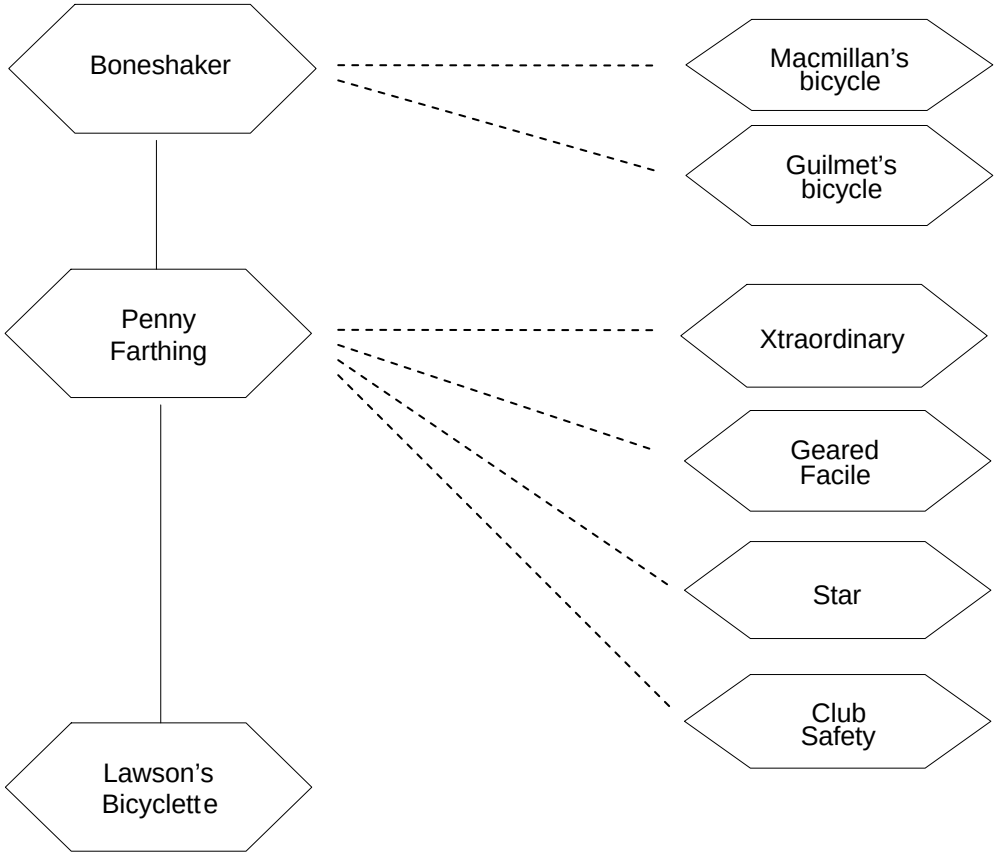
Technology Dynamics

Example: Development of the Bicycle



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Example: Development of the Bicycle

1818
Draisienne

Two-wheeled rider-propelled machine

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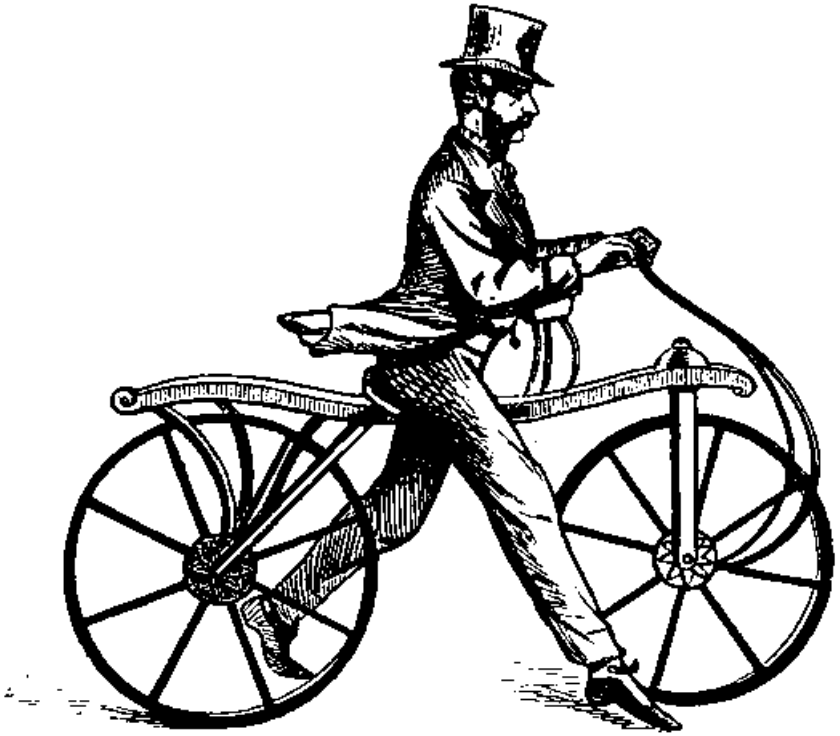
Technology Dynamics

Example: Development of the Bicycle



http://www.phys.uri.edu/~tony/bicycle/draisien.gif

Technology Dynamics

Example: Development of the Bicycle

1861
Michaux

Technology Dynamics

Example: Development of the Bicycle

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Technology Dynamics

Example: Development of the Bicycle

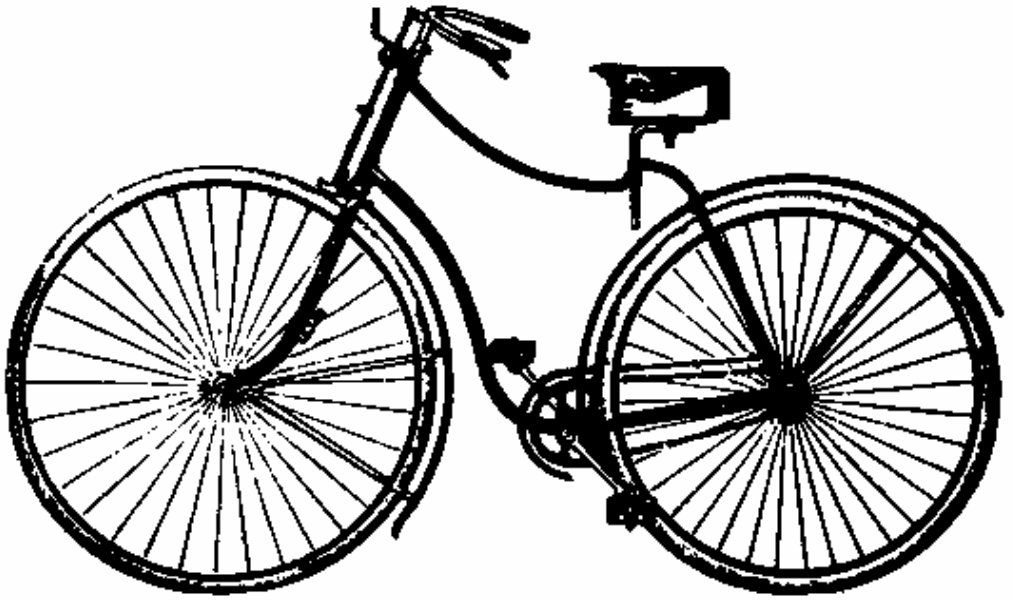
1874

Ariel

Technology Dynamics

Example: Development of the Bicycle

from 1879
Safety bicycles



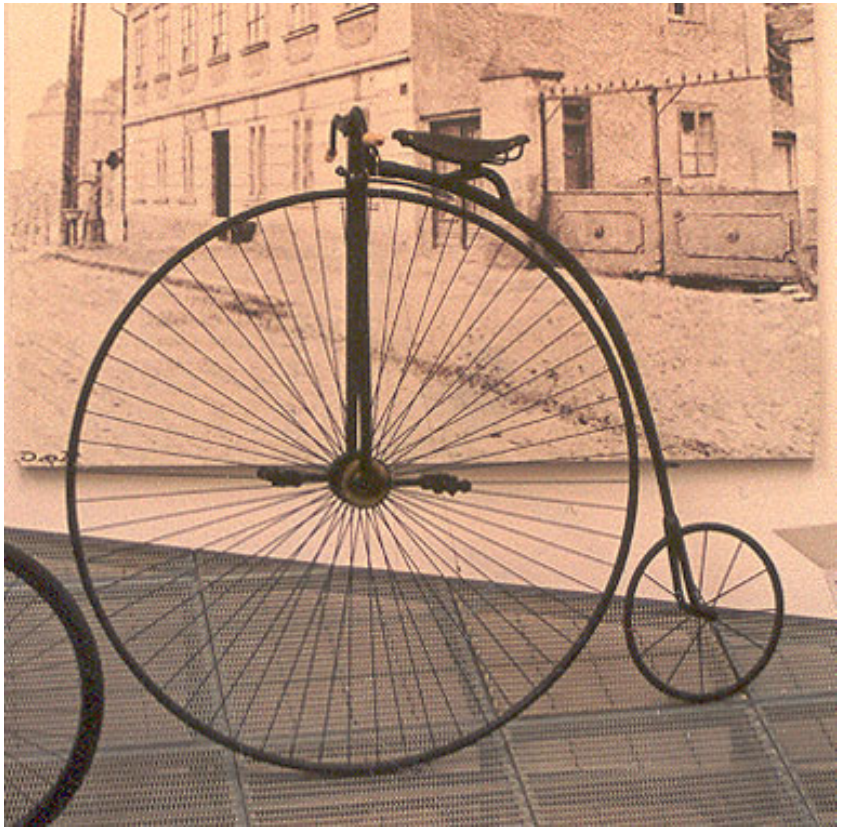
1885 Rover Safety Bicycle http://www.phys.uri.edu/~tony/bicycle/rover.gif

Technology Dynamics

Example: Development of the Bicycle

1890s

Ordinary



http://upload.wikimedia.org/wikipedia/commons/thumb/a/a7/Ordinary_bicycle01.jpg/180px-Ordinary_bicycle01.jpg

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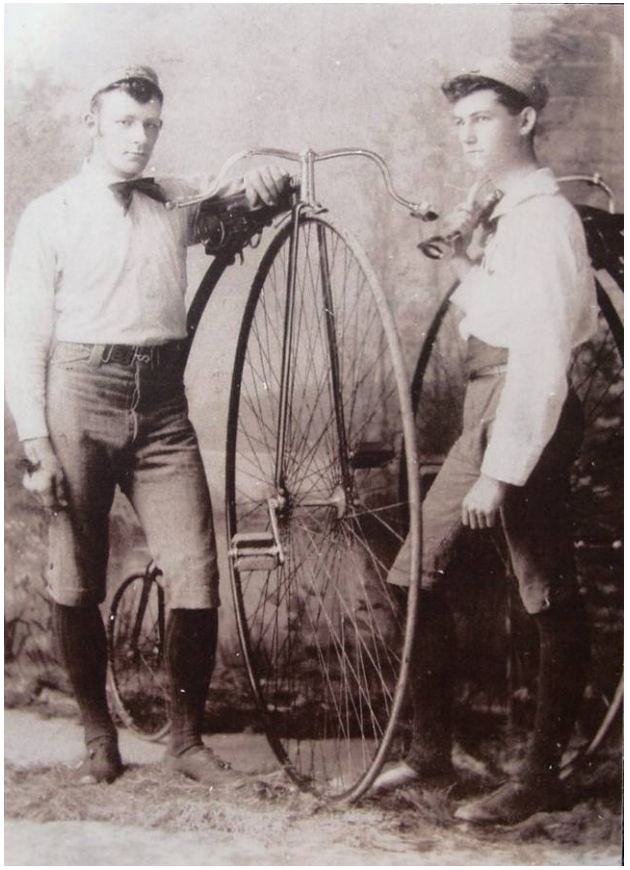
Technology Dynamics

Example: Development of the Bicycle

Penny farthing, up to 1.5 m

Line of development guided by a speed wish sustained by young, sportive men for whom the danger of falling was part of the fun

1893 High wheeler



http://www.bikes.msu.edu/history/web/hi-wheeler-1-P3019443.JPG

Technology Dynamics

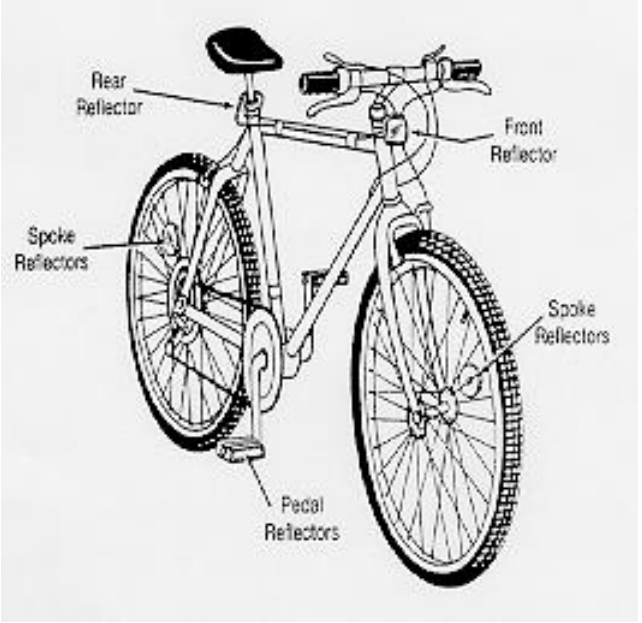
Example: Development of the Bicycle

Safety bike

Reflectors for night riding

Women, recreation cyclists, older people were all interested in the development of a safe and comfortable bike (with brakes, rear wheel drive, pneumatic tires etc.)

Ultimately, interpretative flexibility declined: one (safety) bike, used by all actors, the old and the (included) new actors



http://en.wikipedia.org/wiki/Image:Bicycle.jpg

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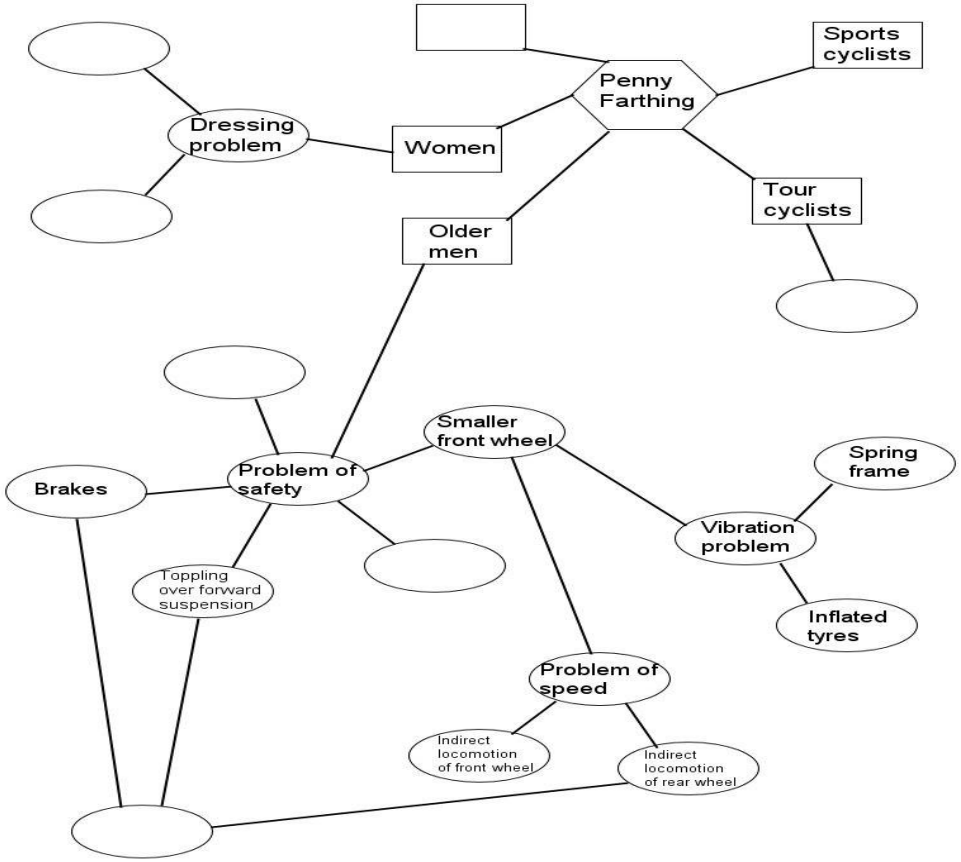
Technology Dynamics

Example: Development of the Bicycle



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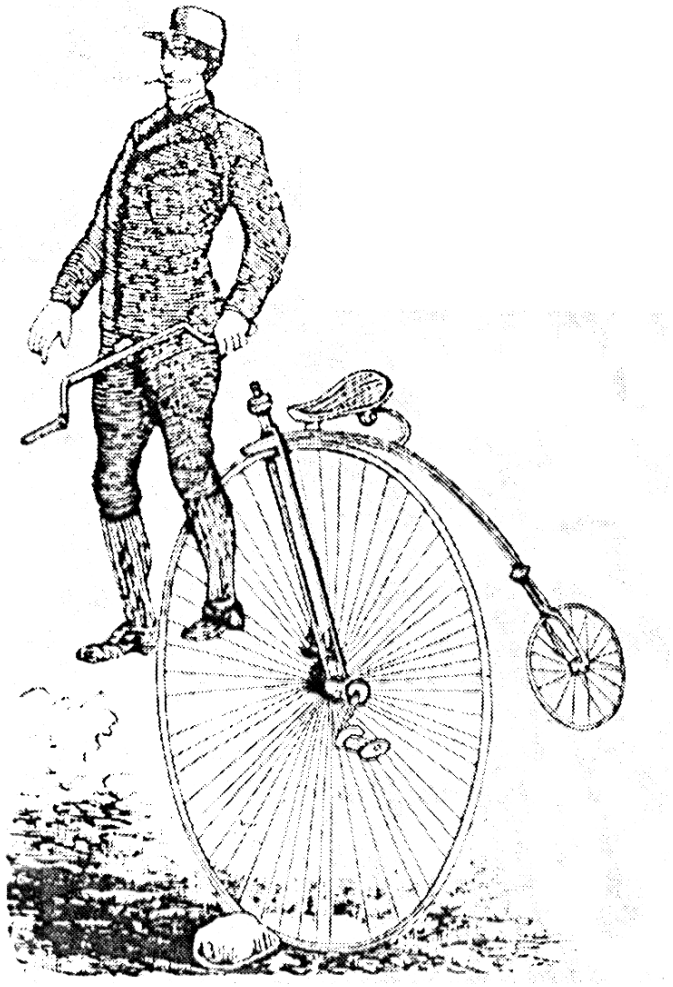
Technology Dynamics

Example: Development of the Bicycle

Solution!



Technology Dynamics

Example: Development of the Bicycle, SCOT-model: concepts

Artifact: bike

Relevant social groups: esp. sportive, young men

Inclusion of new groups: e.g. women and old people

Interpretative flexibility: speed vs safe transportation

Technology Dynamics

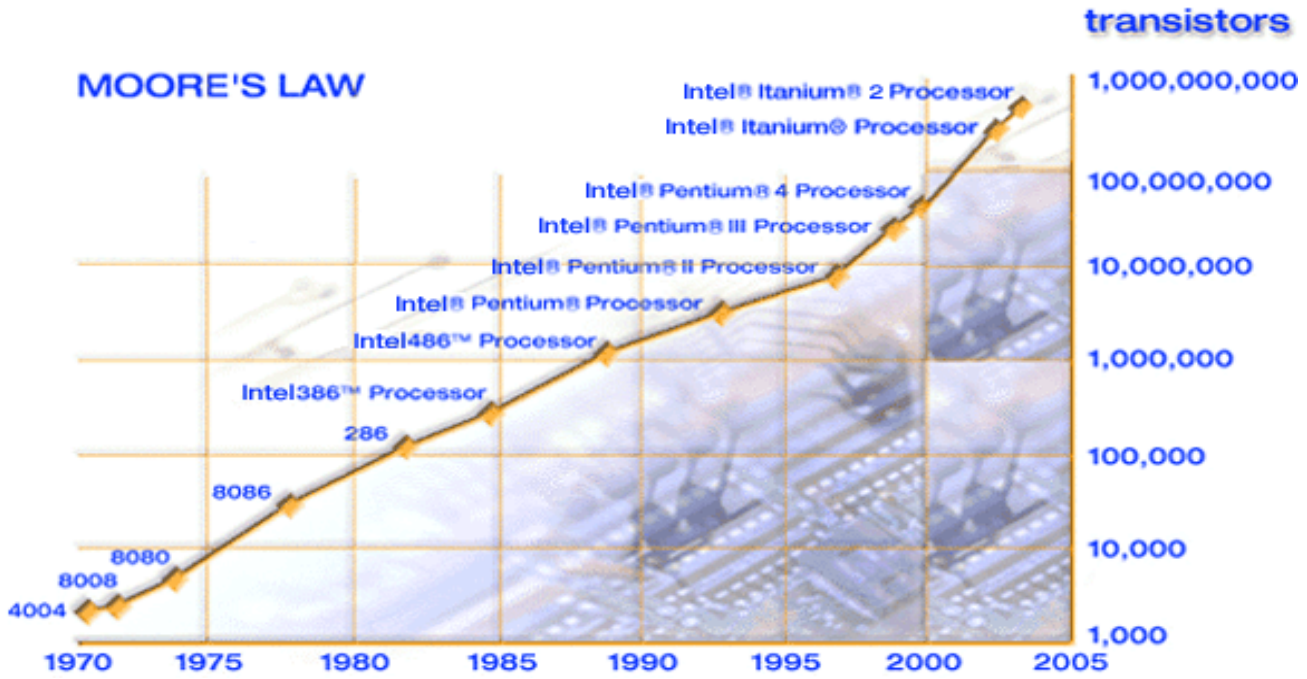
Technological frame

Mindset for design and the solution of problems; mechanical engineering frame

Technological regime: all rules steering engineering design

Technology Dynamics

Technological regime: Moore's law



http://www.seed.slb.com/en/scictr/watch/computer/images/moores_law.jpg

Every 18 months: twice as many IC's on a chip

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Technology Dynamics

Technological regimes

Rules for technological acting:

Design demands and design tools, educational programme

Beliefs and expectations, e.g. Moore's Law

Guiding principles, e.g. digital solutions are preferable

Technology Dynamics

Perspectives

- Actor perceptions, embedded in society and culture
- Engineers regimes, embedded in technology, society and culture
- Other regimes, e.g. political regimes

Technology Dynamics

Regimes

Social-political regimes, e.g. (neo-) colonial policy: exploitation → welfare → development cooperation

Techno-economic regimes, e.g. key technologies with regard to industrial revolution (steam, electricity, ICT)

Technology Dynamics

Sociotechnical systems

Artifact, e.g. sluice

Complex artifact, e.g. sluice complex

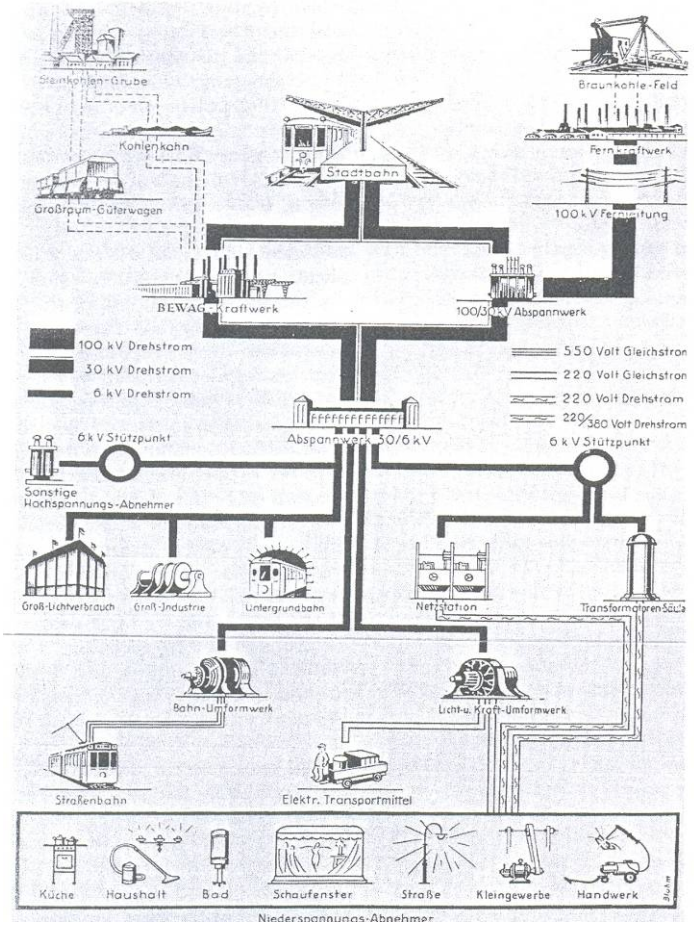
Technical system, e.g. irrigation system of canals and structures

Sociotechnical system, e.g. system of irrigation and management or network of such systems

Technology Dynamics

Electricity System

Universal
supply system
Berlin 1930



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Technology Dynamics

Sociotechnical Systems

A system is constituted of related parts or components

These components are connected: the state, or activity, of one component influences the state, or activity, of other components in the system

Components are often centrally controlled

Limits are established by the extent of this control

Focus is on optimizing the system's performance and on directing the system toward the achievement of goals

Systems reflect and influence their context, but they also develop an internal dynamic: system dynamics vs construction

Technology Dynamics

Sociotechnical System Development

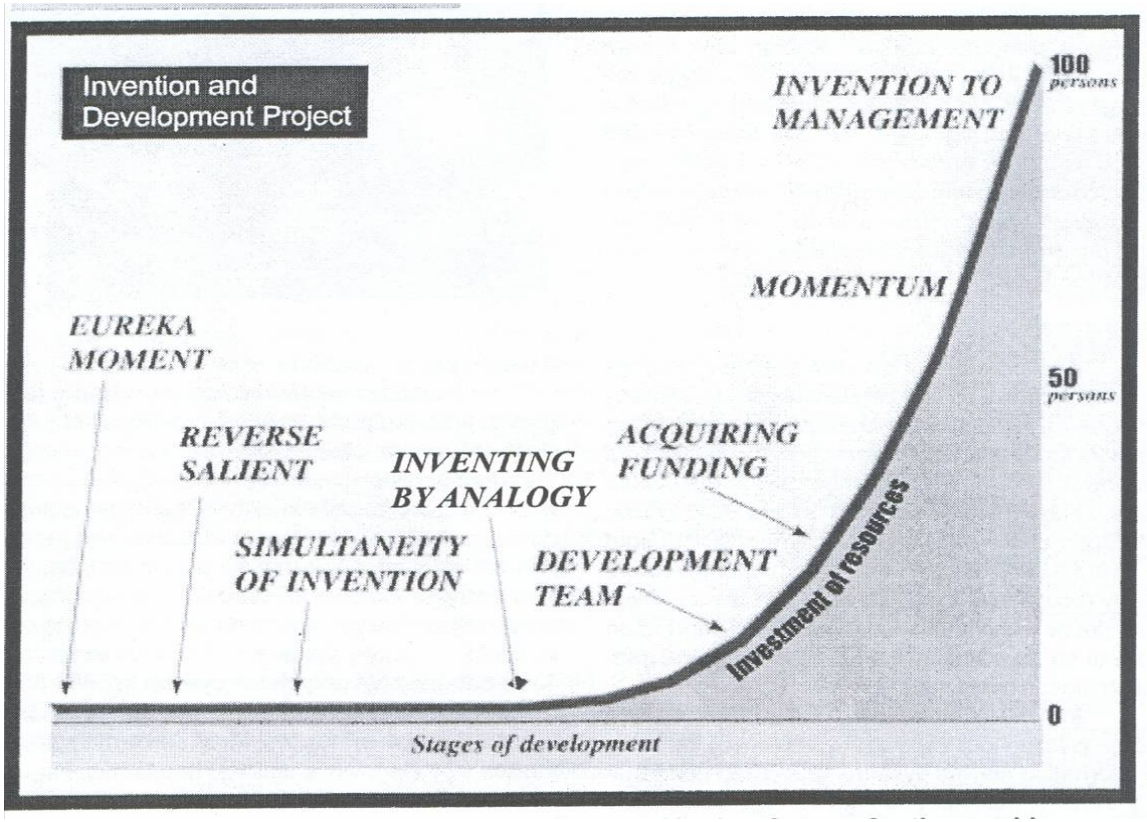
Systems undergo change and development in stages: invention, development, innovation, growth, competition, consolidation and transfer

System mechanisms drive system development: reverse salients, momentum, load factor, economic mix.

System stages characterized by typical actors like Inventor-entrepreneurs, Financier-entrepreneurs and Manager-entrepreneurs / or typical groups of actors / or specific technological regimes

Sociotechnical Systems

System Development and Entrepreneurship



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Sociotechnical Systems

System Development Mechanisms

Momentum: mass, velocity, direction (capital, specific skills, institutionalization, culture)

Reverse salient → critical problems

Load factor

Economic mix

Sociotechnical Systems

Reverse Salient

A reverse salient is a part of the system that is falling behind in its development. It is a nuisance for the system, and might be interpreted differently by various actors., e.g. traffic congestion

A reverse salient might be slumbering or critical

The systems innovative capabilities are directed towards the reverse salients

To attack them successfully, reverse salients have to be reformulated as ‘critical problems’

Sociotechnical Systems

Critical Problem

Reformulation of problem in do-able terms

More than one translation

Translation involves creativity

A good translation greatly increases the likelihood of a solution

Failure to formulate critical problem might stimulate alternative systems

Sociotechnical Systems

Example of Reverse Salient

Edison could only supply nearby down town areas with direct current because of high transmission losses

Several critical problems can be formulated, e.g.

- Reducing transmission losses
- Building cost efficient small scale power stations

Result: new system based on AC: Westinghouse

Sociotechnical Systems

Applications

Other infrasystems like:

- Communication systems: post, telegraph, telephone, telex, fax, mobile telephone as well as papers, radio, television
- Energy systems: gas, oil, nuclear energy, coal, city heating (beside electricity)
- Transport systems: shipping, airliners, roads, railways
- Irrigation, drinking water, sewage

Technical systems like radar, space, systems for organ transplantation etc.

Production and distribution systems, e.g. cars

Sociotechnical Systems

Technology and Society

Sociotechnical systems have developed since the end of the 19th century

According to Thomas Hughes:
Have superseded politics and the economy as the main shaping factors of technology and society.

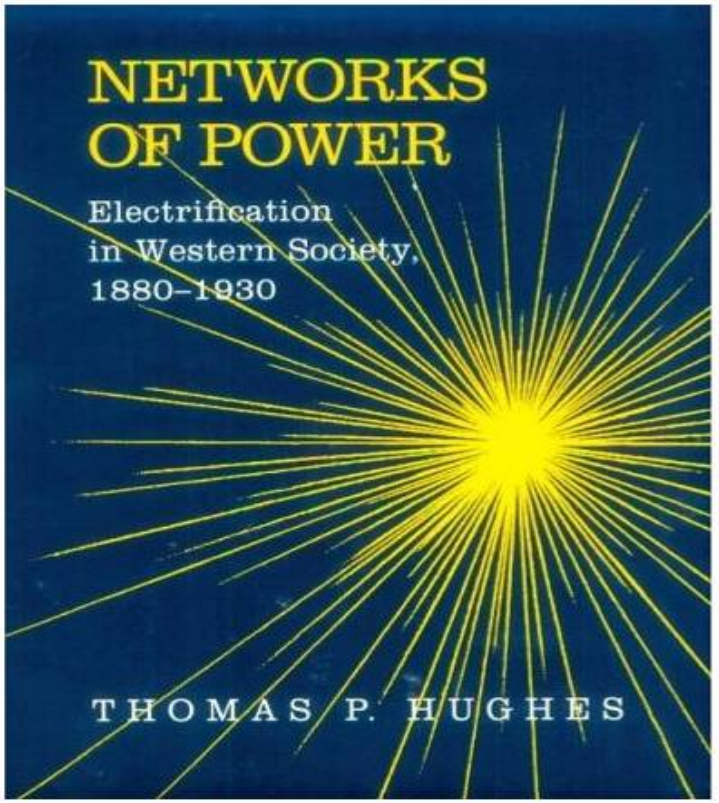

Image: amazon.co.uk

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Sociotechnical Systems

Dutch water system

Polder based administration prevented the solution of problems with big rivers in the 19th Century

Sociotechnical Systems

Dutch water system

Polder based administration prevented the solution of problems with big rivers in the 19th Century:

Draining → milling

Reverse salient in water protection system

Critical problem: dykes, water division of water, canalization?

Ultimate solution was canalization, enabled by another management system

Sociotechnical Systems

Dutch water system

Advanced system building through regime change

Big river problems constituted a reverse salient in water protection system

Polder based administration prevented the solution of these problems in the 18th C →

Change in the political landscape brought the solution: French occupation led to national water agency and strategy

Critical problem: dykes, water division of water, canalization?

Ultimate solution was canalization, enabled by national management system

Sociotechnical Systems

Dutch water system

Open-system building: Oosterscheldekering

Society adjusts

http://www.paulvermast.nl/wp/wp-content/uploads/2007/11/oosterscheldekering-met-storm.jpg
http://static.flickr.com/29/39804088_aad4bad61b_o.jpg

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Sociotechnical Systems

Control Dilemma

Systems theory: in the initial stages the social environment shapes socio-technical system development, later the system shapes society; both in relative terms

Control dilemma:

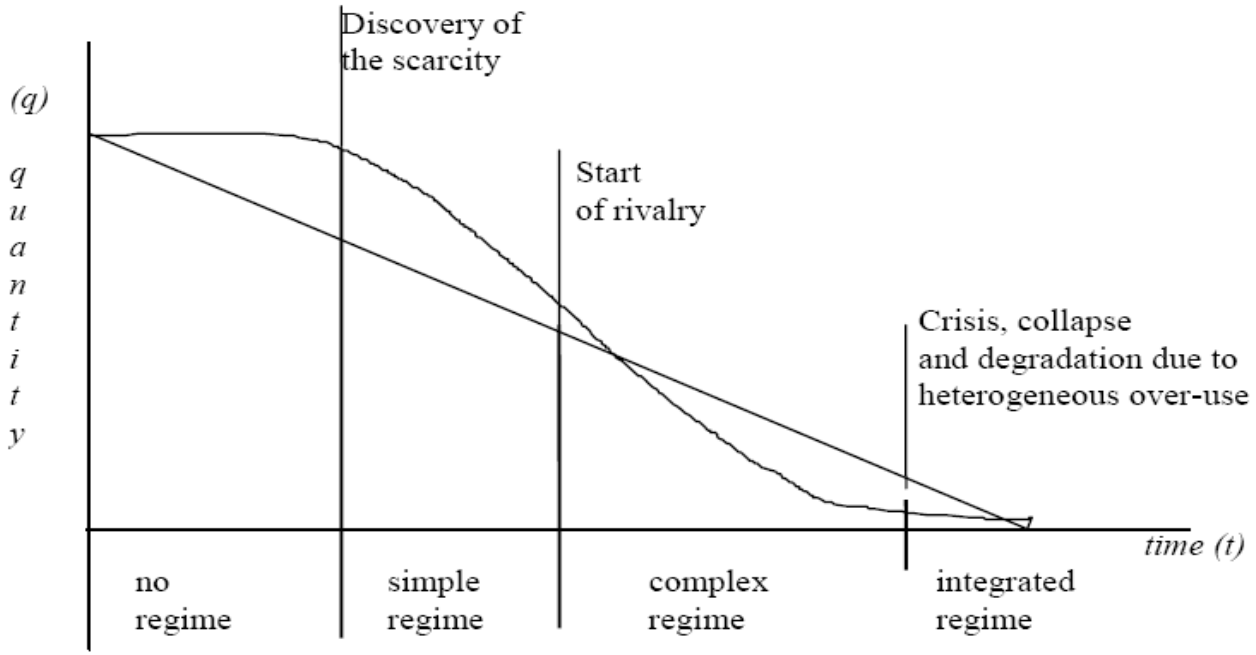
….*attempting to* **control** *a technology is* **difficult**, *and not rarely impossible,* **because during its early stages, when it can be controlled**, *not enough can be known about its harmful* **social consequences** *to warrant controlling its development;* **but by the time these consequences are apparent, control has become costly and slow**.

Collingridge (1980)

Sociotechnical Systems

Water Management Regimes

Figure 1.1: The growing scarcity or degradation of a resource and development of a regime



Source: Swiss study by Knoepfel, Kissling-Näf and Varone, see footnote 1.

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Sociotechnical Systems

Push vs. Pull Debate

Technology push vs market pull / social needs

Sometimes technology develops more quickly than demand / society, sometimes less quickly

Sometimes technology adjusts itself to demand / society, sometimes society adjusts itself to new technology

New technologies often used in another way than meant → change of technology through use / society

Technology and society develop hand in hand

Sociotechnical Systems

Push, Pull and Social Construction

Push:

- STE-complex
- Military-industrial complex: defense, space travel and indutstry (Military = niche market)
- →Social constructions (no laws of nature)

Pull:

- Market demand
- Social problems like sustainability problems
- →Also social constructions (perceptions of needs and problems)

Sociotechnical Systems

Co-construction and co-evolution: actors, systems and regimes

Actors, engineers and social actors, display agency, determined and controlled by factors, esp.:

- Socio-technical systems, hard
- Ware, connecting nature and society
- Technological regimes, software, connecting culture and technology
- Value and philosophical systems, software, connecting actors, society and culture

Group assignment

Investigate the background of China's water problems:

- What causes can be distinguished?
- Which historical solutions have been applied?
- Which processes of variation and selection could be distinguished?