Economics of innovation

ENG-410: Energy supply, economics and transition

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EPFL

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Why we tend to hope for innovation (1)

- imagine we could cheaply and safely generate most of our electricity with new renewables, e.g. with
  - building-integrated photovoltaics
  - geothermal technologies
  - …

Photo: EPFL

- imagine we could cheaply and safely store large amounts of energy to detach energy supply and use, e.g. with adiabatic compressed-air energy storage

(here: pilot project in Pollegio, TI)

Photo: ETHZ

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Why we tend to hope for innovation (2)

- imagine we could use this electricity instead of fossil fuels for almost every energy service, including
  - heating & cooling
  - mobility (even with trucks and airplanes!)
  - …

- imagine we still needed much less electricity, because of
  - smart systems
  - increased efficiency in energy use
  - organizational changes (e.g. efficient virtual meeting rooms)
  - …

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Unsustainable innovation

- driver of (unsustainable?) economic growth
- negative externalities
  - environmental and social risks
  - diffusion -> trade -> transport emissions
  - early obsolescence
    - shorter product life cycles -> higher resource use
  - clustering of new industries?
    - environmental impacts from congestion
- other market failure
  - R&D is fixed cost and thus tends to induce market power
  - asymmetric information about new products (-> lemon effect)

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Static versus dynamic efficiency

Static efficiency

Optimal allocation of resources to generate the highest achievable utility/social welfare

Dynamic efficiency

Optimal allocation of resources to generate the highest achievable intertemporal welfare

Why would a statically efficient resource allocation not be dynamically efficient?

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Why static and dynamic efficiency differ

- time periods are connected
- things change over time, e.g.
  - demographic and economic growth
  - costs and availability of technologies
- change can be influenced, e.g. by
  - savings and investment
  - measures that foster technological progress
- statically efficient solutions may become expensive
  - time-lags because of long replacement periods
  - path dependence and technological lock-in

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Time lags in environmental policy

- dependable research results
- research communication and public recognition
- policy process
- policy implementation
- research
- development
- diffusion (adoption, replacement cycles)
- impact on concentrations of pollutants/GHGs
- reactions of natural systems (humans, ecosystems, climate)

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Innovation

- requires good ideas and means to develop them:
  - institutions
  - knowledge
  - financing
- it's about the innovator's decision, which idea to develop, which depends on
  - personal motivation
  - financing opportunities
  - expected return
  - risk and risk hedging opportunities

} depend on institutions and incentives (applies to: financing opportunities; expected return; risk and risk hedging opportunities)

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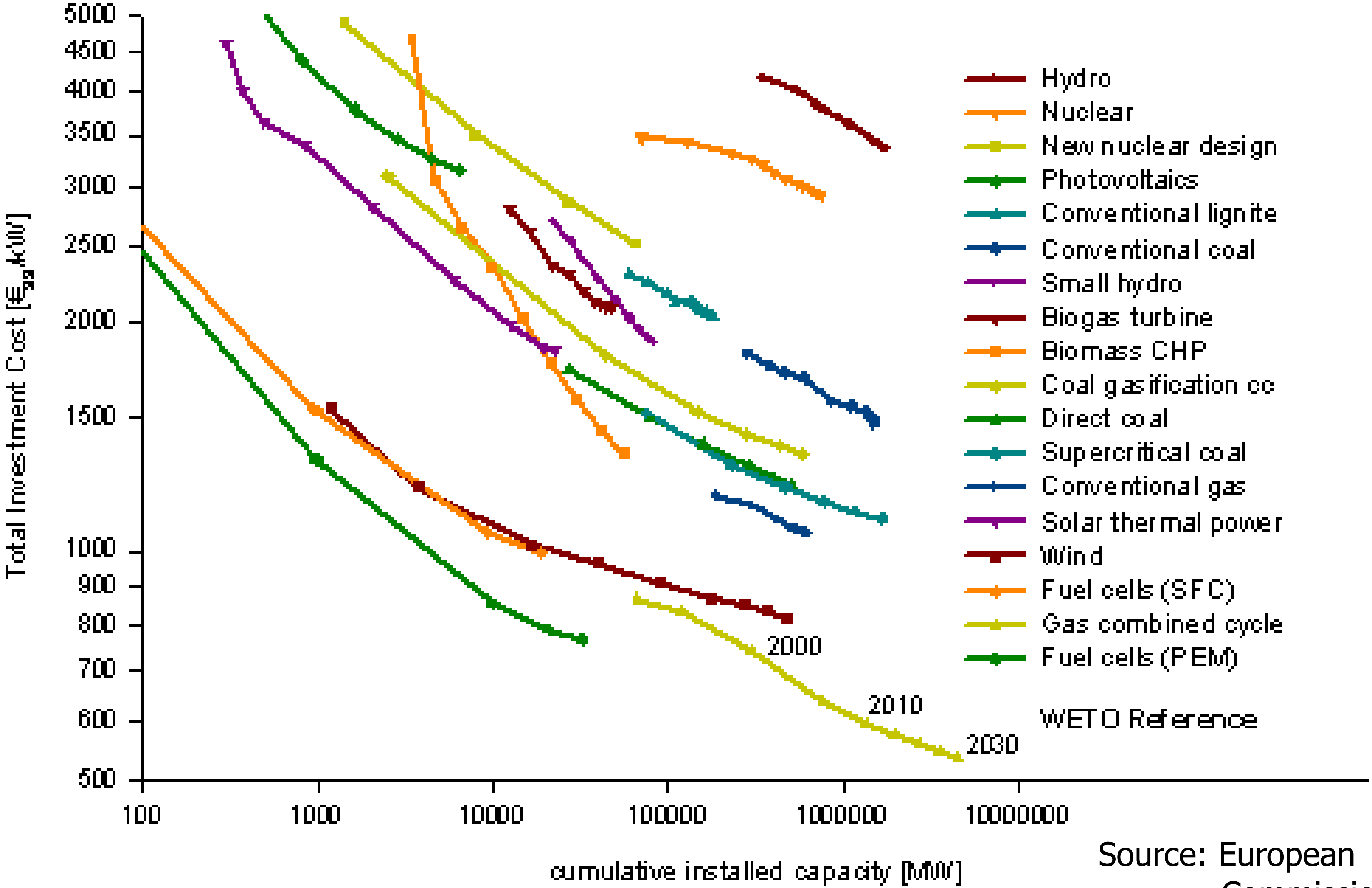
Economics of innovation

Learning by doing



Source: European Commission

Economic characteristics of knowledge

- Production
  - "Joint product": learning-by-doing & learning-by-using
  - Cumulative (knowledge stock), but difficult to reproduce

- Public good?
  - Partially nonexcludable & partially nonrival

    => spillovers / positive external effects

    => free rider problem

    => underinvestment into research and development

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Intellectual Property Rights (IPRs)

- positive expected return needed to avoid free riding and underinvestment
- patents create temporary monopolies (max. 20 years)
  - only for commercially applicable novelties
  - exclusive and tradeable
  - monopoly rents & prices (far) above marginal cost
  - statically inefficient, but dynamically more efficient
- intellectual property rights require public enforcement
  - possible at what geographical scale?

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The knowledge dilemma

- Knowledge is cumulative

  -> Exploit the knowledge commons:

  Cooperate!

- Private investment into knowledge requires the protection of Intellectual Property Rights

  -> Exploit the innovative power of competition:

  Compete for the best solution!

- Which way to go?
  - depends on the type and area of innovation
  - there are hybrid solutions as well

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Types of innovation

- basic
  - science
  - usually publicly funded
  - output (should be) published and made available
  - output is usually non-marketable
- applied
  - technology
  - privately or publicly funded
  - output is often concealed (might be marketable)
- product innovation vs. process innovation
- addressing negative externalities: requires policy incentives to potentially become marketable

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Incentivizing innovation

- Pigouvian taxes and other (dynamic) instruments to internalise external effects
- public R&D spending
- R&D subsidies
- enforcement of intellectual property rights
- funding cooperation
- government procurement
- subsidies for new processes or products
- banning or taxing old processes or products

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The S-shape

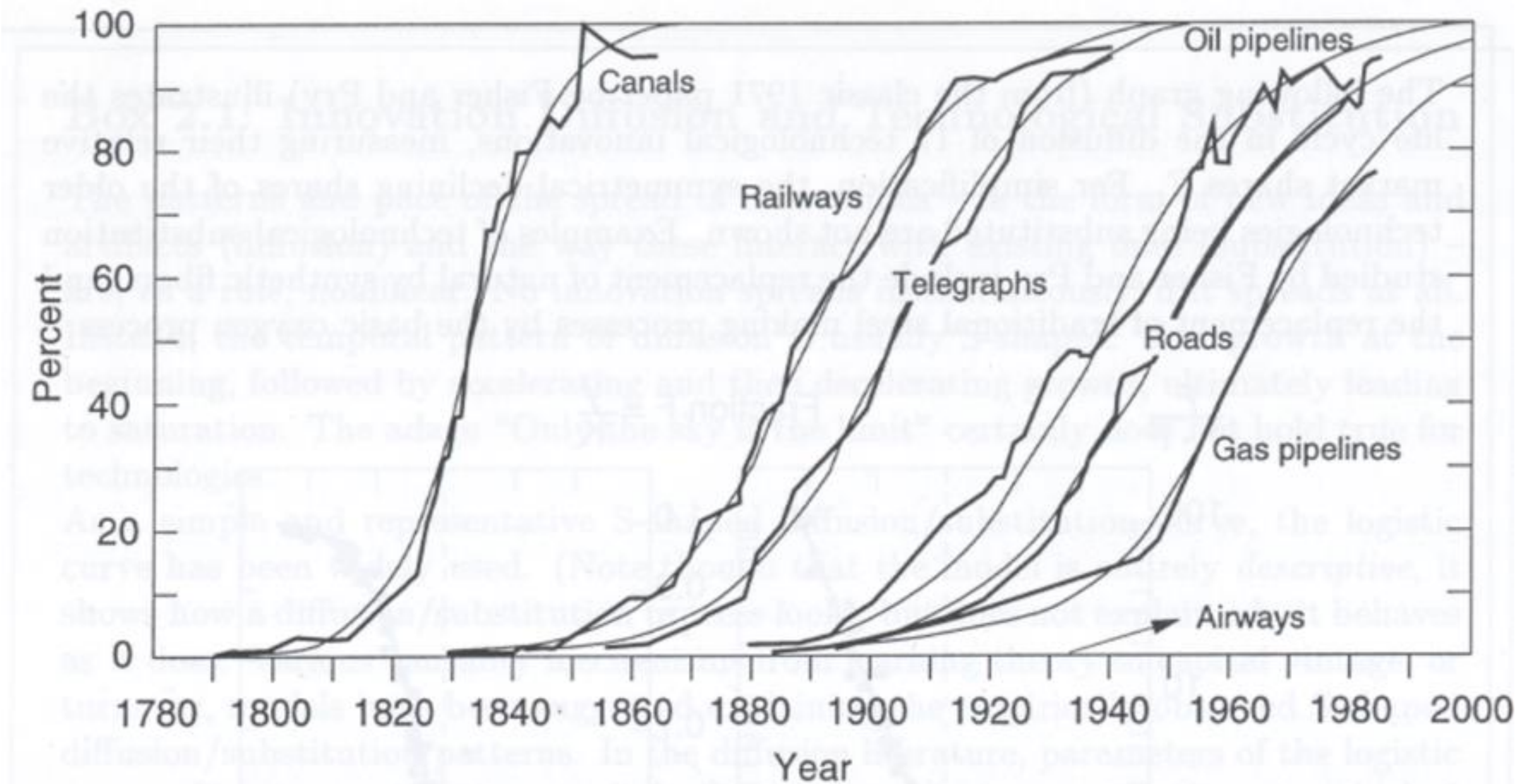
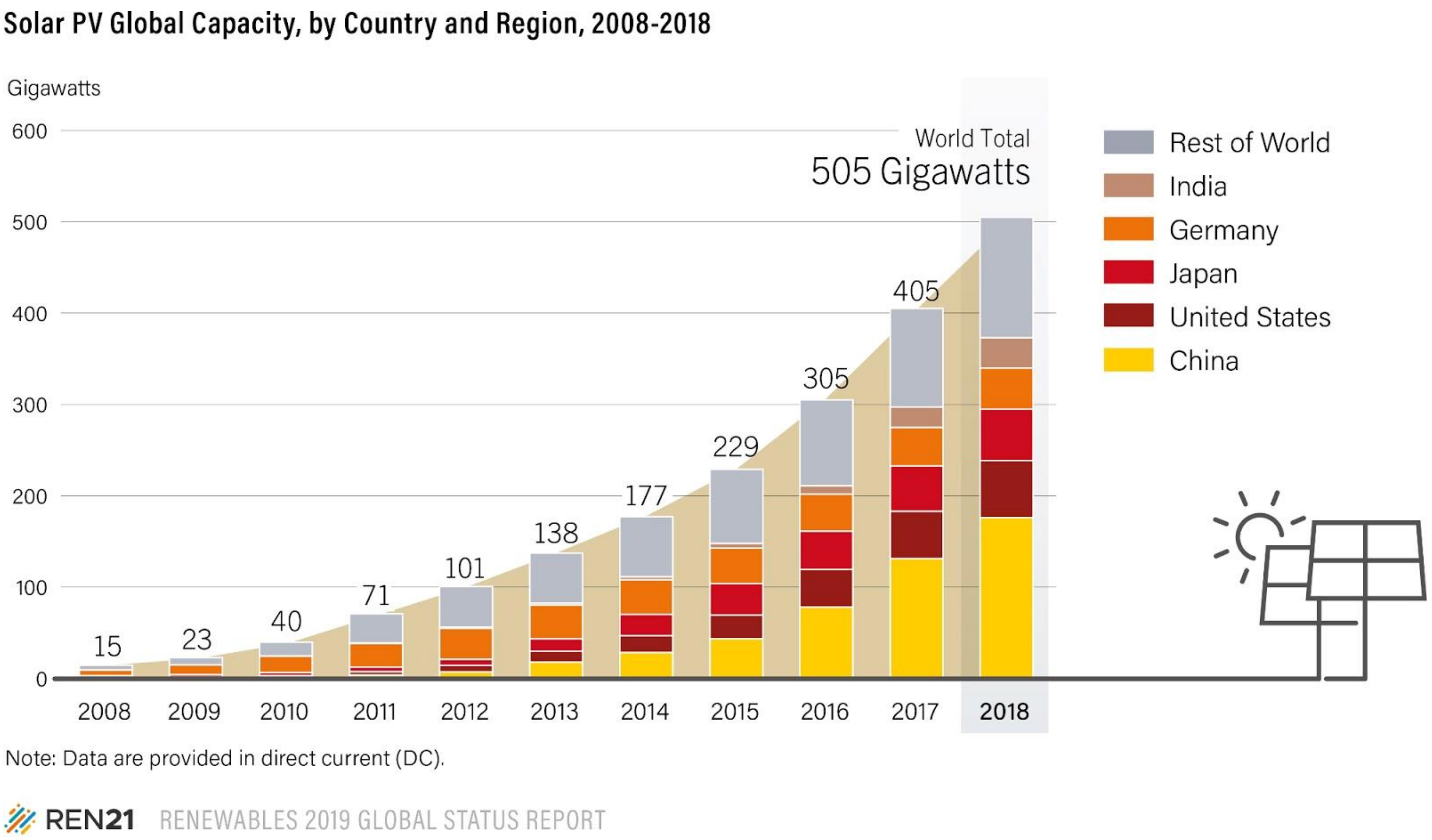


Figure 2.10: Growth of US transport infrastructures as a percentage of their maximum network size, empirical data (bold jagged lines) and model approximation (thin smooth lines). Source: Grübler and Nakićenović (1991).

Cumulative installed PV capacity



Disruptive innovation

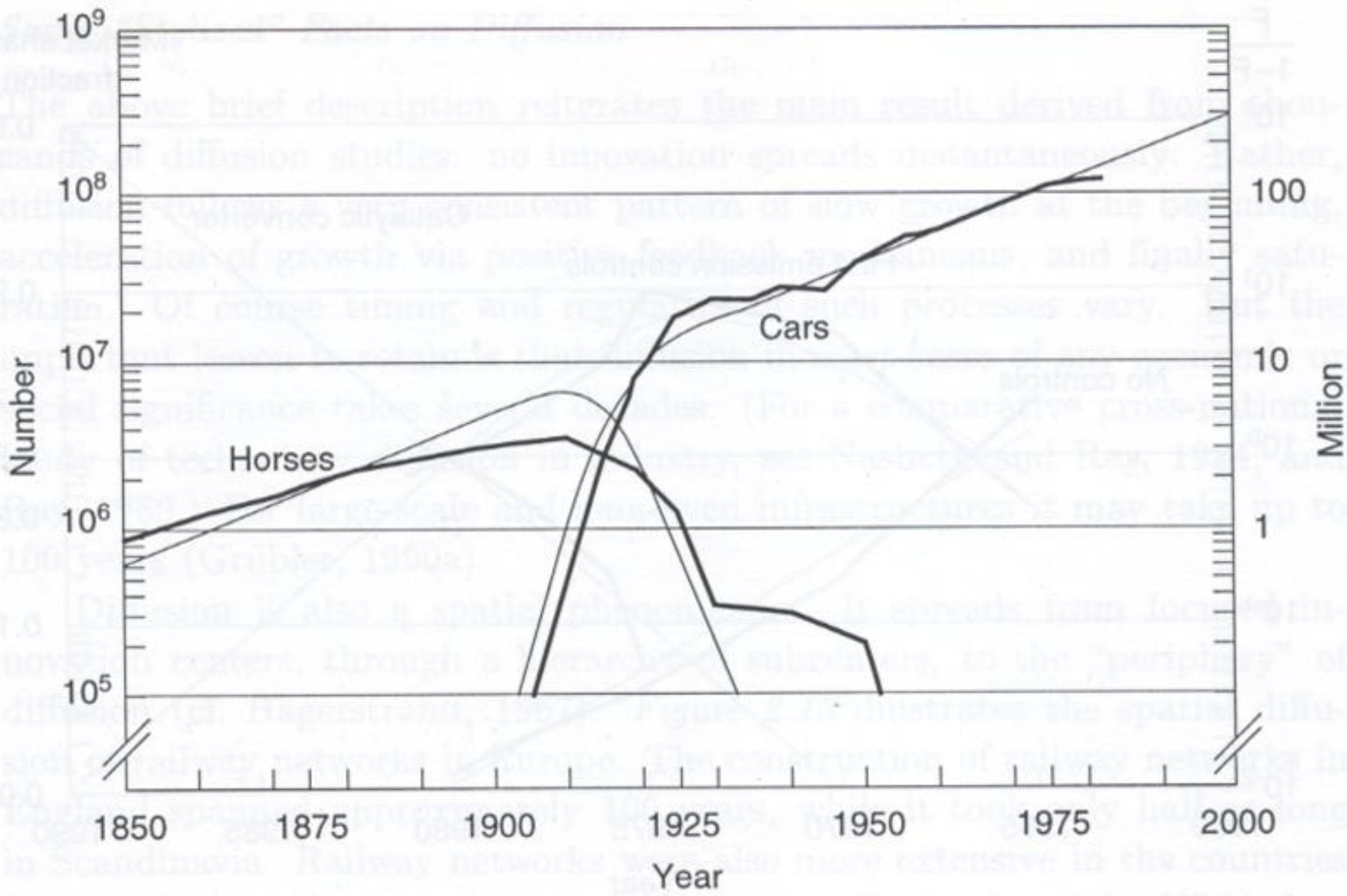


Figure 2.11: Number of (urban) draft animals (horses) and automobiles in the USA, empirical data (bold jagged lines) and estimates (thin smooth lines) from a logistic model of technological substitution. Source: Nakićenović