Designing energy innovation policies for future times

D. Foray

College of Management

Energieforschungsgespräche

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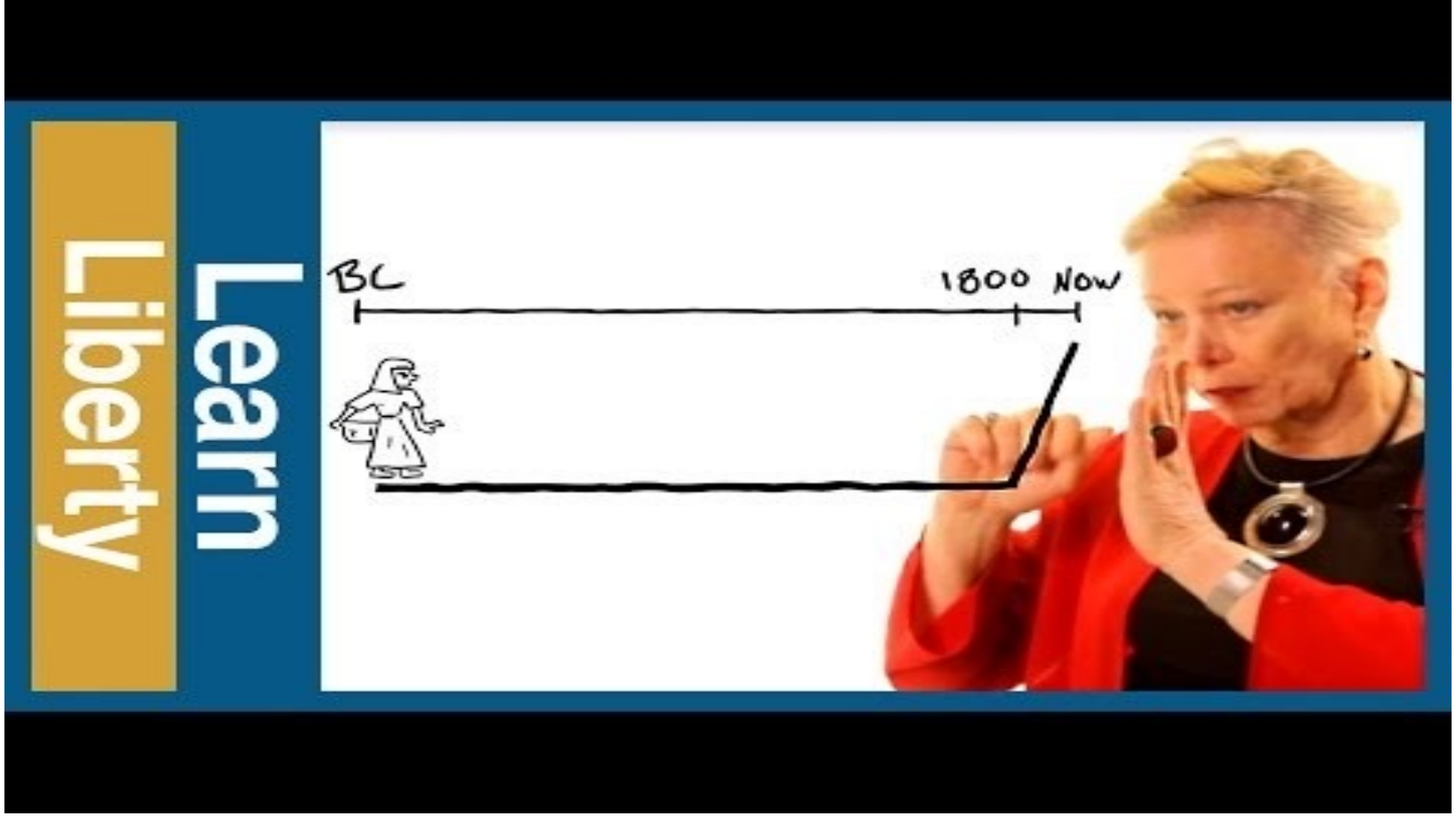
École polytechnique fédérale de Lausanne



D.McCloskey

- Let’s take a step back : admirable..and disappointing
- Redirecting business innovation 1: features which determine returns on investment in innovation
- Redirecting business innovation 2 : policy levers
- The case of renewable energy

Admirable but disappointing…

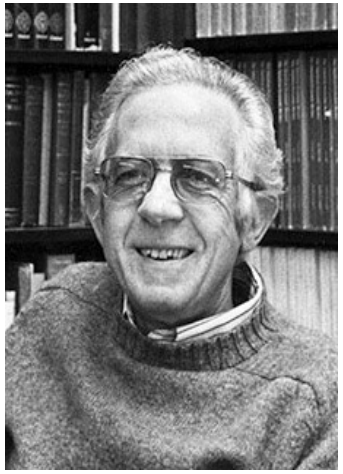
- But this *innovation economics* of the XX° contributed (directly or indirectly) to 4 problems :
  - **The great enrichment is somewhat artificial** – the growth of GDP per capita as boosted by innovation can go with the depreciation of different types of capital (natural, human, social..)
  - **Innovation generates unequality** – neglected areas (not profitable), too complex innovations, unfair innovations, who does innovate ?
  - **Innovation does not produce necessarily ‘’good jobs” -** Human-replacing technologies rather than human-augmenting technologies
  - **Bad innovations are not regulated -** Addictive effects – institutional failures

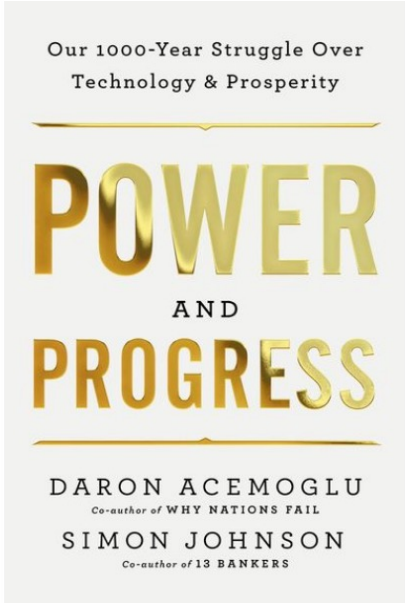
Innovation can't be planned

- Re-directing business innovation – domestication, discipline?

- *« The notion that planning and centralization of decision-making are efficient is the opposite of the truth when there is a high degree of uncertainty and when goals and objectives cannot be clearly defined »* N.Rosenberg

- *« The government cannot be the nerve center of innovation, and bureaucrats are not going to design algorithms or come up with new products »* Acemoglu and Johnson





What should be innovation economics for future times?

- Mainstream (neo-liberal) perspective treats the direction of technical change as essentially exogeneous and out of our control. It is society at large that has to adjust to tech change – not the other way around
- ‘’*the direction of technological change is not autonomous and cannot be left to the firms and innovators alone” (Atkinson, 2015)*
- The direction of innovation responds to economic incentives and prevailing social norms
- This talk address the fundamental tension between ‘’maintaining the modern values of freedom (to experiment) and autonomy” and ”re-directing innovation”

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- A model to identify the main features that determine returns on innovation investments – **demand – supply – institutions – policy**
- How to improve some of these features within areas/sectors where ‘’more innovations’’ is socially desirable – e.g. how to re-direct technological change?
- Based on Jones (2020) and Cornet, McDonald & Foray (2023)

Demand : expanding demand drives more innovation

Scale – total addressable market, potential for increasing returns to scale

Consumer preference & price – willingness to pay

Uncertainty and salience
Consumer uncertainty about the ‘’utility’’ of an innovation versus ‘’salience’’

Diffusion
Diffusion not impeded by exogeneous factors – durability of assets, installed base, regulation

Demand : expanding demand & high wtp drive more innovation

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Consumer preference & price – high willingness to pay

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Adoption costs
Diffusion not impeded by exogeneous factors – durability of assets, installed base, regulation

Supply: costs decline and rising tech opportunities drive more innovation

Fixed costs of creating new products or processes
Two components – the industry agnostic cost of creating new business – the sector specific costs of R&D and experimentation

Falling costs of entrepreneurial experimentations

- Cost of experimentation matters – differences in the costs across sectors can influence the start ups that investors choose to fund
- Falling cost *associated with the creation of business* is a broad trend in many sectors
  - That have benefited from Internet, open source software, cloud computing, etc..
- Falling costs which are *sector specific* involve for example technologies which are smaller and modular – reducing the need for large capital costs
- Falling costs democratize entry and encourage innovation in 'difficult' sectors
  - When costs of experimentation dramatically decrease - this makes it possible for smaller pools of capital to find viable opportunities: angel networks, accelerators, incubators, crowd funding – « spray and pray »
  - When a plethora of very small start up experiments can be run, investors naturally arise
  - Capital will flow from areas with more costly experiments to those with less costly experiments

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Per unit production costs and per unit sales costs
scalability

Nature (science and technological) opportunities

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Nature (technological) opportunities

Institutional parts of the innovation system are manifold

Appropriability
Intellectual property, Innovators don’t need to share surplus (internal finance, complementary assets, market spillover)

Market structure
Competition vs monopolies

Basic research

Finance
Availaibility of external finance

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Nature opportunities
Varying technological opportunities

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Market structure
Competition vs (regulated) monopolies

Basic research and KTT

Finance
Availaibility of external finance

Energy price
Strong effects if other features are favourable

Policy - markets need to be repaired (not laisser-faire)

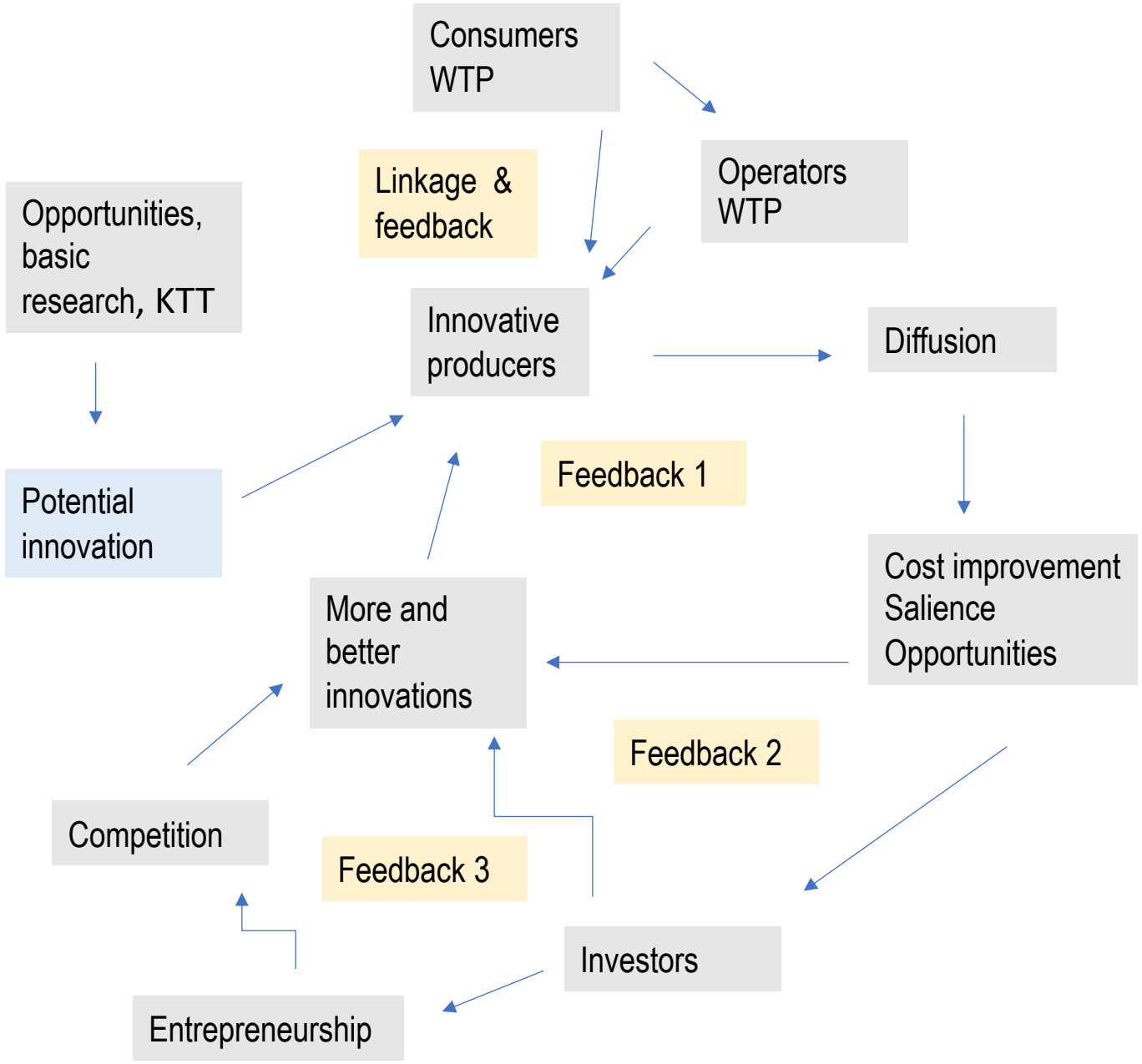
Repairing markets - 1
Negative externalities of the existing technologies – are they priced?

Repairing markets - 2
Fixing market failures for innovation – knowledge externalities (incl adoption ext), unhedged uncertainty

Feedback loop and path dependence – how to get started?

- **Feedback loop** : A technology becomes better and cheaper as it is adopted and produced at large scale
  - Immediate benefits becomes obvious and wtp is increasing
  - More adoption and more costs improvement
  - Compatibilities and inter-relatedness are established within larger systems
  - Investors get involved – more entries, more competition

- **Path-dependence** makes the new technology inferior today although it will have many advantages in the future
  - Comparing the new tech with the existing tech at T0 is misleading. We should compare the existing tech at T0 with the future perf of the new tech at T5 (if it would have been adopted)


Consumers WTP
Linkage & feedback
Operators WTP
Opportunities, basic research, KTT
Innovative producers
Diffusion
Potential innovation
Feedback 1
Cost improvement Salience Opportunities
More and better innovations
Feedback 2
Competition
Feedback 3
Investors
Entrepreneurship

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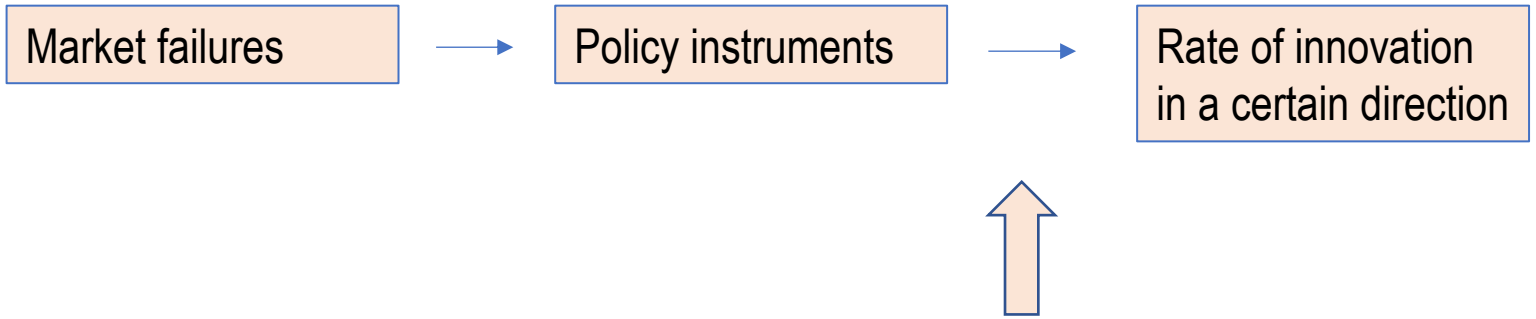

Constraints of innovation policy design and implementation

Industry public inputs are highly specific

Innovation policies involve the support of ‘’system of complementarities”

Ex ante identification of projects featuring low private and high social returns

Monitoring and control in context of uncertainty and assymetric information

Market failures

- Environmental externalities
- Innovation spillovers
  - A part of the value of the considered innovation is not fully incorporated in market prices – market, knowledge, network spillovers
- Adoption spillovers
  - Early adopters generate information and learning of public relevance
- Unhedged uncertainty
  - In general uncertainty does not harm economic efficiency as long as risks can be suitably hedged
  - But the problem with financing innovation is that the financier cannot observe the effort of the potential innovator (principal-agent problem – the *agen*t has private information that the *principal* does not know)
  - Because of this fact: innovation involves uncertainties which cannot be fully hedged because the success depends on unobservable effort by the innovator – it may be hard for small firms to raise funding at a decent interest rate
- Coordination failure
  - Business model's innovation make sense only when other, complementary models are already in place.
  - If all technologies and systems were realized together, they would form a self-sustaining system with potentially important profits.
  - But there are a lot of obstacles where the success of a given project depends on the success of another
- Information failure – consumers or users are unable to easily evaluate the new good, adopters wait for more information

The innovation policy toolbox - 1

Push logic – instruments address the cost of innovation

Direct provision of research and KTT

R&D subsidies and grants

R&D tax credit

Early adoption subsidies

Push policies – the agency pays for the inputs with no certainty about success – uneasy to monitor both level and direction of effort - the public agency bears most of the risk

Pull logic – instruments address expected revenues (reward)

Patent system

Prize

Advanced market commitment

Pull policies– the agency pays for the output – leaves investment to the private sector which bears most of the risk

Information logic

Instruments address information failures and uncertainty at various stages

Coordination logic – instruments address potential coordination failures arising from the strategic complementarites among investments

ARPA mechanism – under strong supervision and oversight, a program supports a network of partners to achieve a specific technological development

Coordination policies are not about tools in a narrow sense but general approaches to support systems of complementarities

Absolute neutral
Select fields but technology neutral
Target a specific technology

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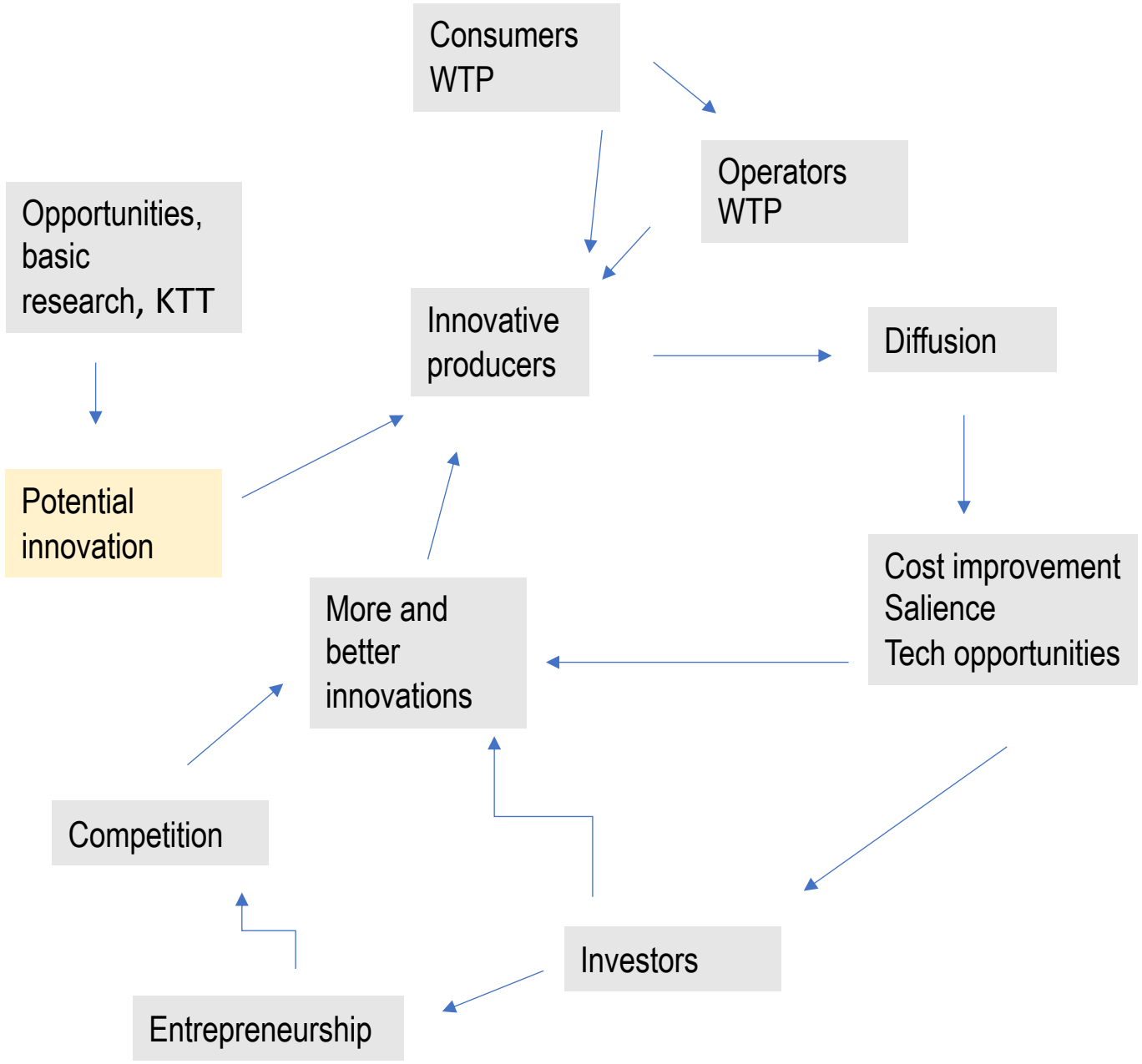


Unique features of energy innovation system as impediments before 2010

Innovation sensitive to exogeneous price fluctuations

Consumers unwilling to pay a premium for clean energy (commodity market)

Operator's incentives

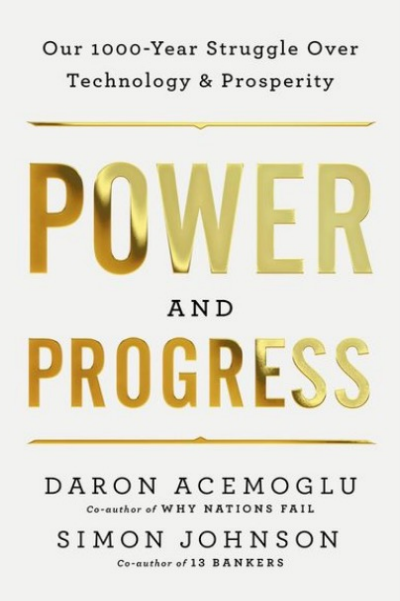
The VC – start up model faces many impediments – long time horizon from ideas to market, fixed cost, expensive to scale, no exit through acquisitions by utilities and other large energy companies

Other impediments – assets duration, grid integration

Innovation proceeded slowly and entrepreneurship played a minor role

Redirecting business innovation - renewable energy

- Today, solar, wind energy are cheaper to operate than fossil-fuel power stations
- How did this impressive achievement take place?
  - Narratives shape behaviours and decisions
  - Policy levers (environment and innovation)
  - Positive feedbacks
  - Industrial (rather than innovation) policy



- «*Due to technological trajectories set in motion by past policy, a global irreversible solar tipping point may have passed where solar energy gradually comes to dominate global electricity markets without any further climate policies* » (Njisse et al., 2023).

Energy source	Cost per 100 kWh $
Fossil fuels	50 - 150
Photovoltaic solar	40 - 54
Onshore wind power	> 40

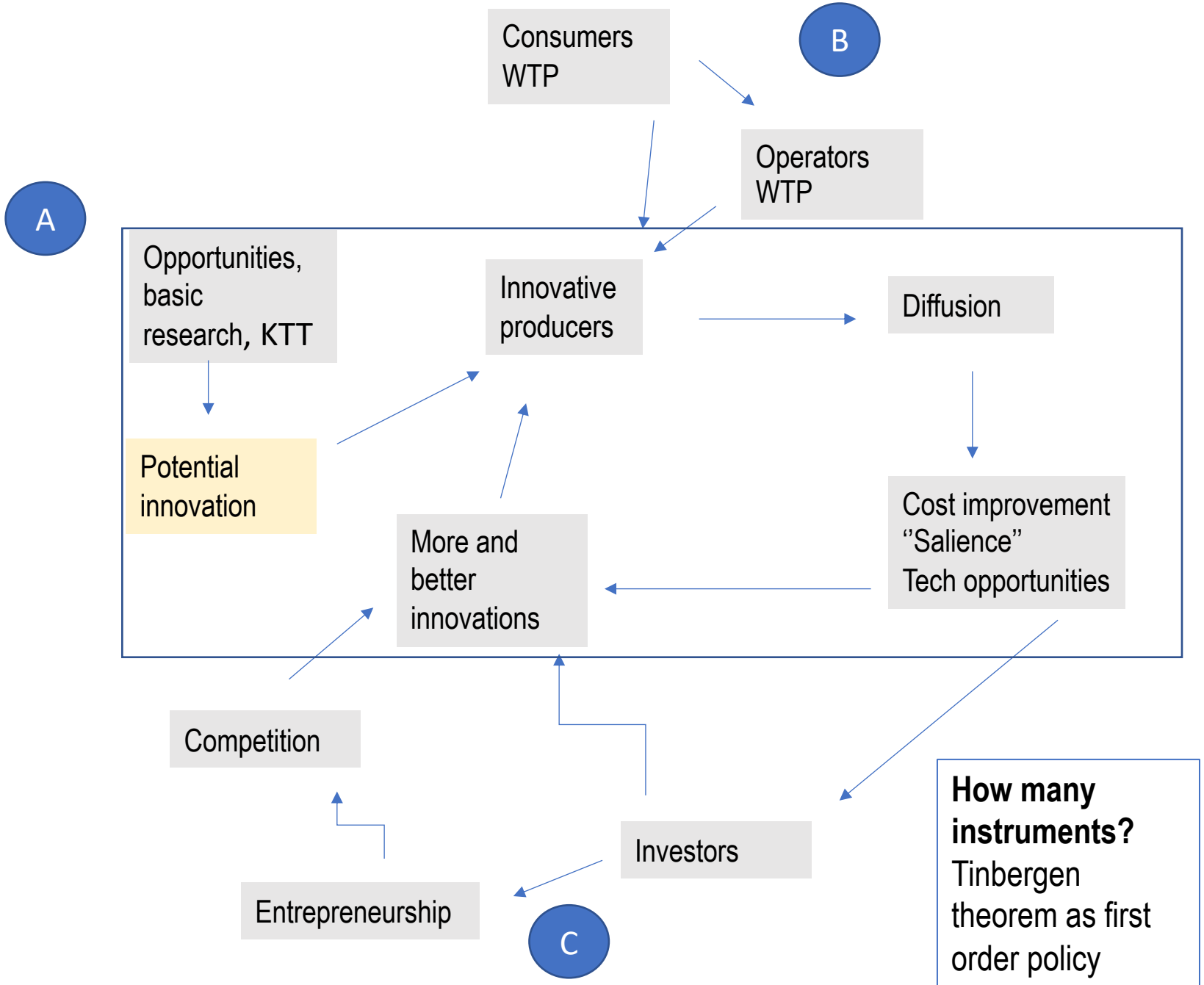
The importance of narratives or *Grand Récit*

- To explain how business innovations can be re-directed:
- « *First came the change in narrative* » Acemoglu and Johnson
- Narratives include a major societal problem and the solutions – this is shared in society and reaches some level of consensus
- The power of the narrative – which can be appreciated by the strength of social norms and values it generates – has obvious implications on consumers, innovators & firms and investors decisions
- But the narrative can be more or less (un)easy to construct

Problem & solutions	The problem is wicked (complex, uncertain, contested)	Urgency	The solutions are clear and non ambiguous	Winners and loosers?	Construction of the narrative
COVID	No	Yes	Yes	No loosers	Easy
Climate & energy (before 2010)	Yes	No	No	Many loosers	Uneasy
Climate & energy (after 2010)	No	Moderate	No	Many loosers	Less uneasy

Redirecting business innovation - renewable energy

- The change in narrative
  - Shapes decisions and behaviours of consumers, innovators and investors
- Policy levers – environment & innovation
- Positive feedbacks outcomes
  - Narrative, consumer cares, willingness to pay, operators and innovators
  - Falling fixed cost - New technologies are often smaller and modular – reducing the need for large capital costs
  - Diffusion: Spectacular cost improvements (production, operation, integration)
  - Investors' tractions, entrepreneurship and competition
  - Capacity increases



How many instruments?
Tinbergen theorem as first order policy guidance

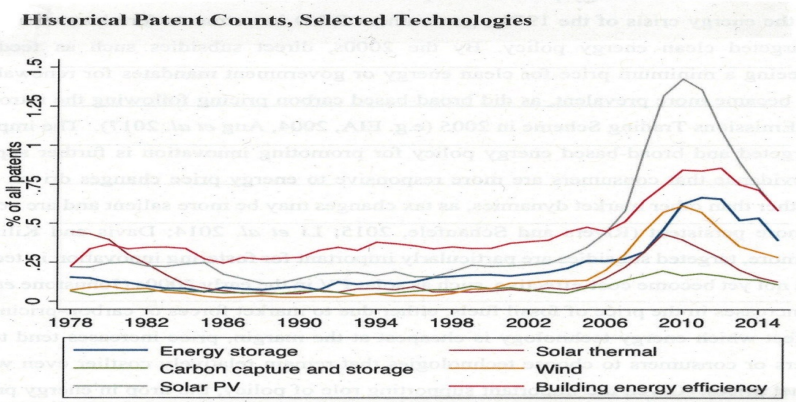
A – R&D policy (push, pull, coordination, salience)
Broad mandates
Pushing the advance of knowledge
Grants, subsidies, direct provision
Targeting specific development
Prizes, advanced market commitment
Addressing blatant coordination failures
ARPA
Subsidizing early adoption, public procurement Multiple effects

B – Policy-induced market expansion
Broad mandates
Feed-in tariff
Information provision (narrative)

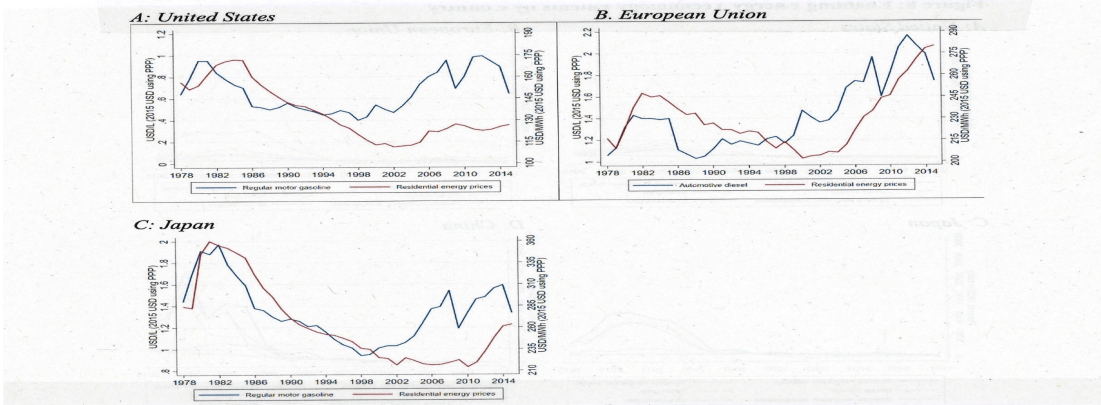
C – Entrepreneurship policy
Subsidizing early stage when de-risking is hard
Support investors,
Angels tax credit
Address coordination failures
Incubators, accelerators


Merci

Innovation follows energy prices



Energy prices, selected countries
Regular motor gasoline
Residential energy prices



Popp, et al. – Innovation and entrepreneurship in the energy sector, 2021

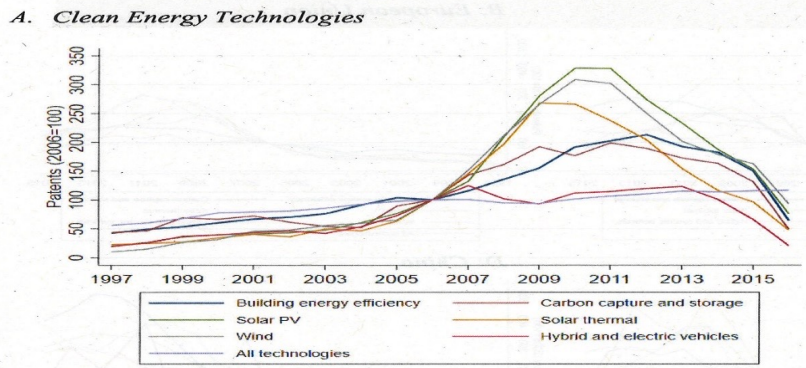
Patenting activity increases when energy prices rise

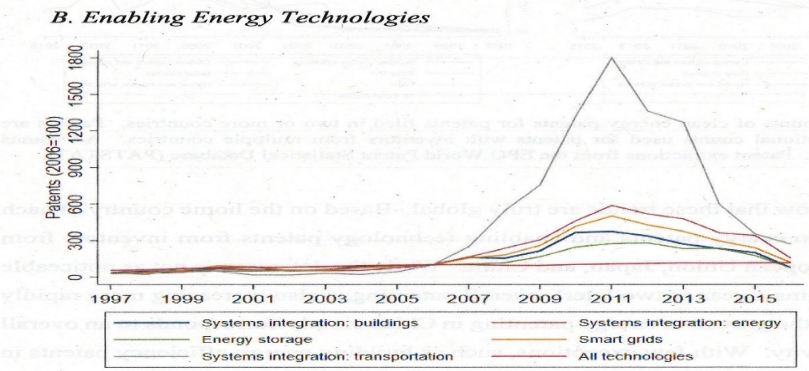
The innovation policy toolbox - 2

	Neutral in all dimensions	Non neutral (areas) technology neutral	Technology specific
Push	R&D tax credit, subsidies and grants	Direct provision Subsidies related to a thematic priority	Direct provision
Pull	Patent system		Prizes Advanced market commitment Public procurement
Coordination			ARPA
Information	Advice and education	Information provision	Information provision

Redirecting business innovation - renewable energy

- Essential features to detemine returns on innovation investments were not favourable
- Before 2010:
- Consumers are unwilling to pay a premium for clean energy
- High fixed costs, capital intensive, long time horizons
- Small scale, costly products for small groups of customers with special needs
  - Cost per watt much higher than fossil fuels
  - No cost improvement
- Environment policy unstable and unreliable – maintaining competitive advantages for fossil energies
- Investors stayed away after an initial excitement





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