Assessing the Impact of Basic Research on Society and the Economy

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Structure of presentation

Why do we need to assess impact of basic research?

Problems in measuring the impact

Methodological approaches

- Econometric studies
- Surveys
- Case-studies

Empirical findings

Different types of ‘exploitation channel’

Policy implications

Conclusions

Why do we need to assess impact?

Debates on why government should fund science and at what level

Researchers feel never enough funds

Despite complaints, government funding of research continued to grow in real terms

Now a significant proportion of GDP (~2-3% in most OECD countries)

Hence demands for accountability & assessment

Science not always seen as high political priority cf. e.g. health, education, pensions

How to persuade governments to invest more?

Measuring the impact of research

How great are the benefits, and are they greater than the level of investment?

Question suggests simple linear model

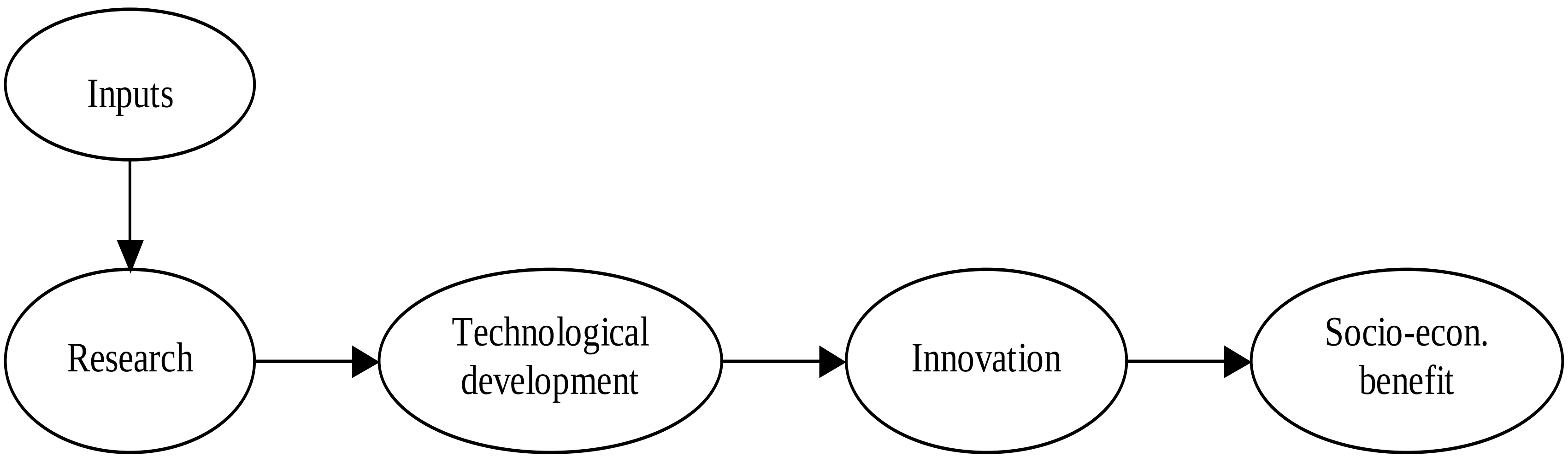

Figure 1: Simple linear (‘science-push’) model

The linear model

Scientific discoveries in early 20th Century & WW2 ➔ belief in linear model of innovation

Government responsibility = to fund basic research – will eventually ➔ wealth, health & national security

Not very explicit re exact form of benefits nor when

Widely adopted after 1945

Used to justify substantial increases in gov't funding of science over next 50 years

Viewed as investment in future welfare

BUT now recognise major problems with linear model

Problems in measuring impact

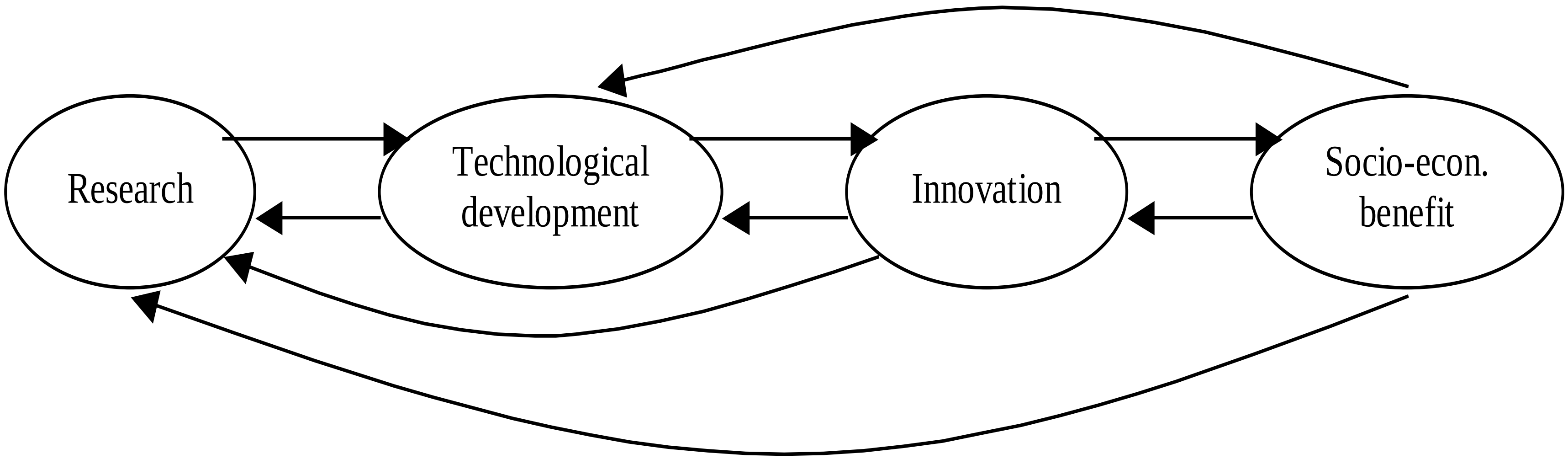

Figure 2: Chain-link model

Relationship of science to innovation not linear but 2-way – development of ‘chain-link’ model (Kline & Rosenberg)

‘Causality problem’ – not clear what benefits can be attributed to what cause (Martin & Tang)

Problems in measuring impact

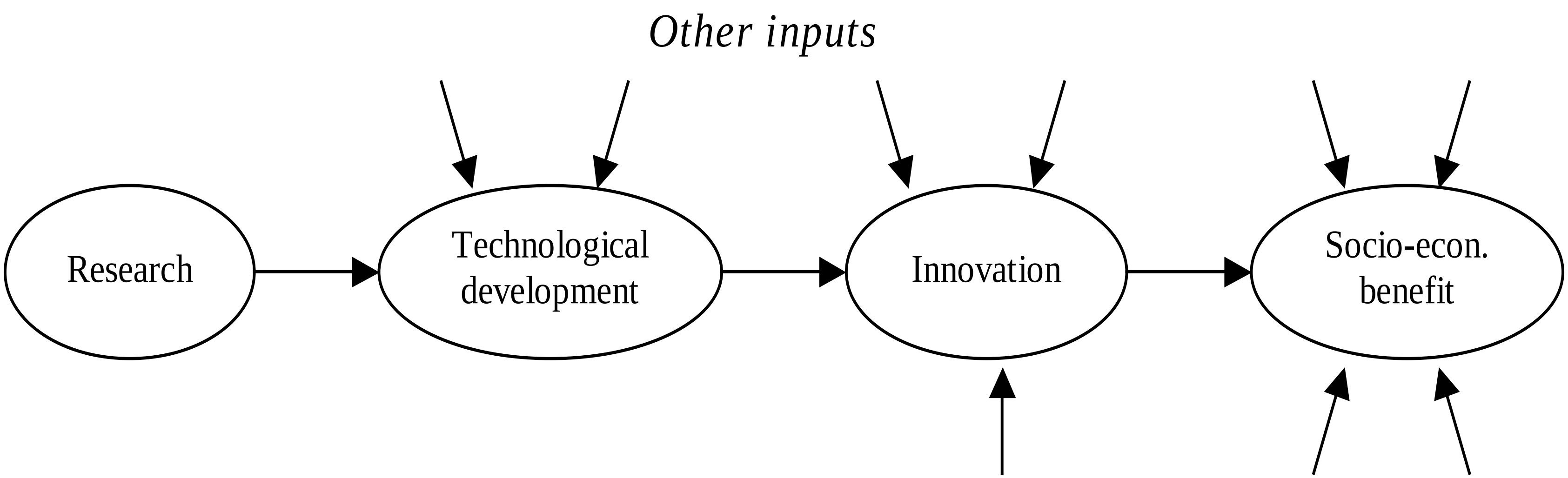

Figure 3: The effects of other factors

Other non-research inputs to innovation e.g. ‘trial & error’, mkt research, customer feedback, organisational improvements

‘Attribution problem’ – what portion of benefits should be attributed to initial research cf. other inputs? (ibid.)

Problems in measuring impact

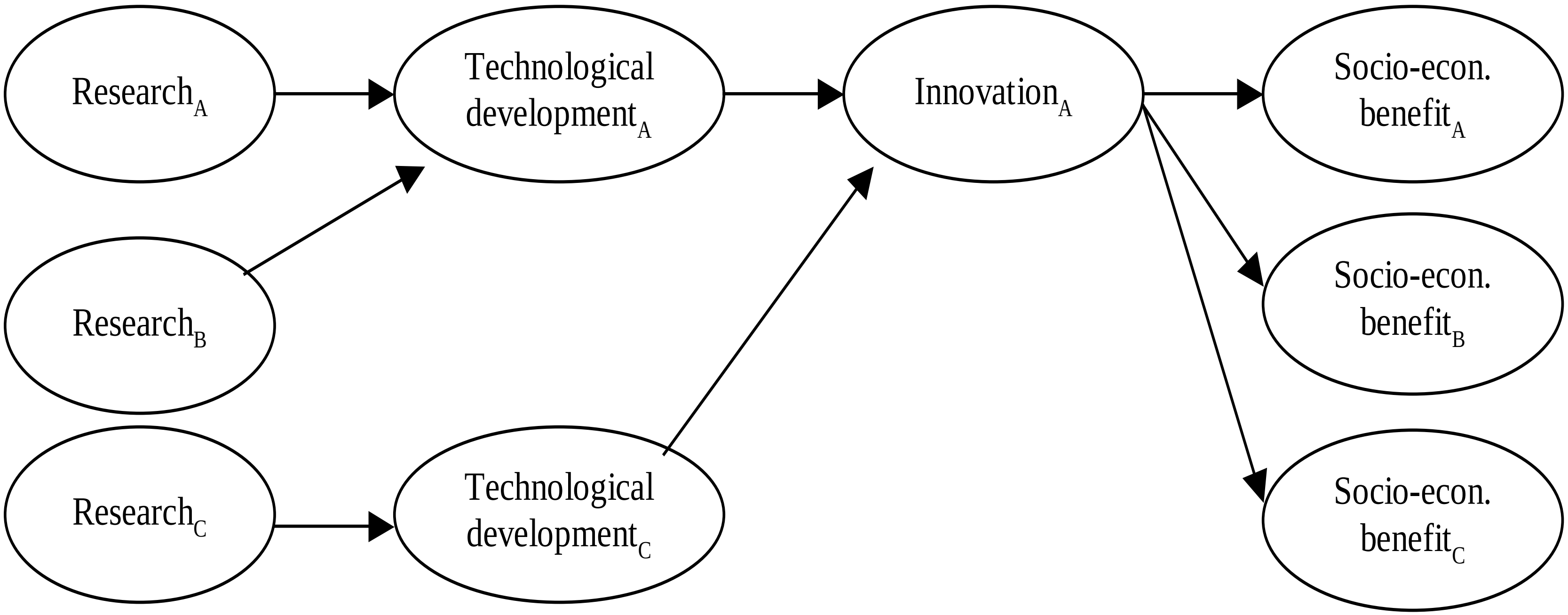

Figure 4: Cross-country effects (where 'Research$_A$' means research conducted in Country A, etc.)

'Internationality problem' – S&T and innovation are intrinsically (and increasingly?) international – again makes attribution virtually impossible (ibid.)

Problems in measuring impact

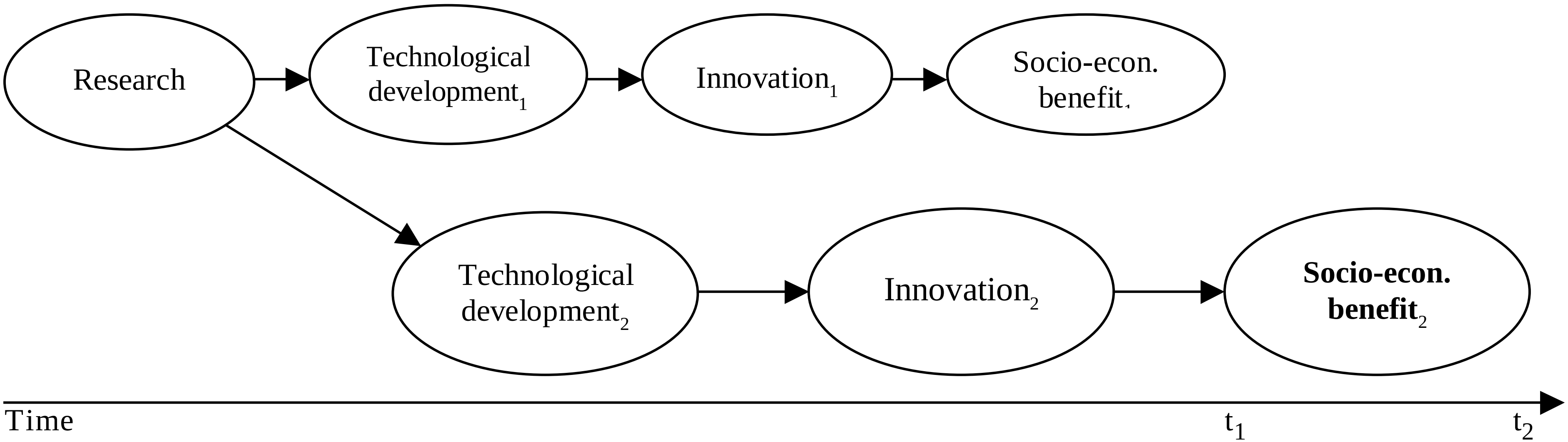

Figure 5: Effects of assessing the benefits prematurely

Timescale from research to innovation can be decades

'Evaluation timescale problem' – premature measurement (at time t_1) may result in policies that over-emphasise research bringing short-term benefits (ibid.)

Problems in measuring impact

Intrinsic limits in extent to which assessment of impact of research can be quantified

- No perfect measures, only imperfect or partial indicators (e.g. publications, citations, patents, licensing revenue, spin-off companies)

Linear model assumes that output of research is new scientific knowledge in a codified form

- But tacit knowledge (embodied in trained people) equally important

Methodological approaches

1. Econometric studies
2. Surveys
3. Case studies

Methodological approaches

1. Econometric studies

- statistical analysis of large databases
- focus on large-scale patterns
- provide aggregate picture of statistical regularities
- useful in estimating rate of return to research

BUT

- involve simplistic or unrealistic assumptions about nature of innovation
- very difficult to trace impact of research through process of tech development, innovation and commercialisation

(Martin et al., 1996; Salter et al., 2000; Salter & Martin, 2001; Scott et al., 2002; Martin & Tang, 2006)

Methodological approaches

2. Surveys

- e.g. of industrial R&D managers
- analyse extent to which research constitutes a source of innovative ideas for firms
- understand how different industries utilise research results from different scientific fields

BUT

- tend to focus on large firms only
- survey respondents from firms may have a bias towards internal activities of own companies
- respondents tend to have limited knowledge of their sectors and technologies

Methodological approaches

3. Case studies

- attempt to trace all historical inputs to innovation
- best tool to examine directly the innovation process and changes over time
- show substantial influence of research in key innovations

BUT

- focus mainly on ‘successful’ innovations
- expensive to administer & can take a long time to analyse
- yield only a narrow picture of reality – difficult to generalise

Econometric results

Early growth models (e.g. Solow)

- explored portion of growth not attributable to labour and capital inputs
- attributed residual to technological change

Numerous empirical studies of rates of return

- Virtually all found large rates of return

Distinguished private VS social rate of return

- For industrial R&D, social rate of return (40-60%) typically double private rate of return (20-30%)
- For publicly funded R&D, rate of return typically 20-50%

Rates of return from public R&D

Studies	Subject	Rate of return to public R&D (%)
Griliches (1958)	Hybrid corn	20-40
Peterson (1967)	Poultry	21-25
Schmitz-Seckler (1970)	Tomato harvester	37-46
Griliches (1968)	Agricultural research	35-40
Evenson (1968)	Agricultural research	28-47
Davis (1979)	Agricultural research	37
Evenson (1979)	Agricultural research	45
Davis & Peterson (1981)	Agricultural research	37
Huffman & Evenson (1993)	Agricultural research	43-67

Source: Griliches (1995) and OTA (1986)

Econometric results

BUT tended to

- focus on ‘successful’ R&D programmes
- ignore other inputs to innovation (‘attribution problem’)
- focus on research as source of useful knowledge and to ignore other major exploitation channels (see below)

Treated technology as exogenous

Cf. New growth theory (Romer)

- attempts to take account of technology more directly
- suggests key role played by technology in generating economic development

Survey results

Mansfield – interviewed US industrial R&D managers to assess impact of academic research on firms' innovations

- ~10% of innovations would have been greatly delayed & ~2% of innovations lost without academic research
- Estimated rate of return = 28%
- Results replicated by Beise & Stahl in Germany

But underplays other 'downstream' inputs to innovation?

Yale survey of US industrial R&D managers (Klevorick et al.)

- show certain sectors draw heavily on university research

Confirmed by PACE survey of European R&D managers

Indicators - patent citations

Narin et al. – rapid growth in dependence of patents on results of publicly funded basic research – i.e. science-technology links increasing (although varies with sector)

Case-study results

Studies (e.g. Griliches; Jaffe; Saxenian) show that research produces substantial ‘spillovers’

- Geographical
  - linked to localisation effects – e.g. person-embodied nature of much knowledge
- across industrial sectors
  - reflecting personal interactions

Spillovers

- contribute to development of agglomerations or ‘clusters’ (e.g. Feldman & Florida) – shape a region’s capacity to innovate (e.g. Route 128, Silicon Valley – Saxenian)
- a primary mechanism of growth in new growth theory (e.g. Romer; Grossman & Helpman)

Types of research impact

SPRU taxonomy of 'exploitation channels'

1. Increasing the stock of useful knowledge
2. Training skilled graduates
3. Creating new scientific instrumentation & methodologies
4. Forming networks and stimulating social interaction
5. Increasing the capacity for technological problem-solving
6. Creating new firms
7. Provision of social knowledge

Extensive literature shows

- substantial benefits for each of these channels
- some more readily measurable than others

(Martin et al., 1996; Salter et al., 2000; Salter & Martin, 2001; Scott et al., 2002; Martin & Tang, 2006)

Types of impact

1. Increasing the stock of useful knowledge

- Traditional justification for public funding ('market failure' rationale)
- Focuses on codified knowledge – underplays tacit dimension of knowledge and costs of acquiring and exploiting scientific knowledge
  - firms need an 'absorptive capacity', as do countries
- Extensive evidence of substantial impact e.g.
  - PACE survey of large European firms – shows some sectors rely heavily on scientific publications (Arundel et al.)
  - Studies of biomedical research (e.g. Comroe & Dripps; Lasker; Murphy)

Types of impact

2. Training skilled graduates

- Arguably the primary form of impact of academic research (e.g. Gibbons & Johnston; Martin & Irvine)
  - Points to importance of combining teaching and basic research in same institutions
- Bring tacit as well as codified knowledge
  - Skills e.g. research, problem-solving, capacity to learn
  - Techniques e.g. instrumentational
- But very difficult to quantify impact

Types of impact

3. New instrumentation and methodologies

- A key output of government-funded research
- Many examples
  - electron diffraction, synchrotron radiation, scanning electron microscope, ion implantation, superconducting magnets etc.
- Benefits flow both ways –
  - new instrumentation may open up new research (e.g. artificial intelligence)
- Rated highly in surveys of firms (e.g. Klevorick et al.; Arundel et al.) but few attempts to measure
  - V difficult for ind R&D mangers to quantify effect of earlier publicly-funded research

Types of impact

4. Forming networks & stimulating interactions

- Publicly funded research provides entry point to networks of expertise and practice ('invisible colleges' – de Solla Price)
  - Firms often tap into these (Darby et al.)
- Basic research may also generate
  - new networks (strengthening the national innovation system – Lundvall)
  - new sources of variety (Callon)
- Density of networks may be an indicator of vibrancy of regional or national economy (Cooke and Morgan)
- But economic impact very difficult to quantify

Types of impact

5. Increasing capacity for problem-solving

- Firms need to combine technologies in complex ways – raises numerous problems to be resolved
- Publicly funded research provides trained problem-solvers (e.g. Vincenti; Patel & Pavitt)
- Rated as important by R&D managers (e.g. Yale & PACE surveys)
- Insights from more basic research often trickle down to industry via e.g. engineering schools (Nelson & Rosenberg)

Types of impact

6. Creating new firms

- Researchers & students may spin out of universities to exploit new ideas and technologies
- Some spectacular examples of regional clusters e.g. around MIT, Stanford, Cambridge
- Research ‘stars’ often central (Zucker & Darby)
- But overall evidence on impact rather mixed
  - Many spin-offs remain small or fail
  - Academics tend not to make good entrepreneurs
- Wide variations with sector and region
  - Importance of other factors e.g. availability of venture capital

Types of impact

7. Provision of social knowledge

- Introduction of innovation often involves social issues/ challenges requiring inputs from social sciences
  - e.g. environmental issues, health care, public acceptance of new technology, govt policy (social, health, education, S&T etc.)
- Social sciences provided basis for various public goods
  - e.g. national statistics, censuses, economic models, management
- Arts and humanities also becoming more important
  - e.g. to ‘creative industries’ (design, advertising etc.)
- Few empirical studies on impact

Policy implications

Relative importance of each type of exploitation channel varies with

- scientific field
- technology
- industrial sector

'Measurability' of each channel varies considerably

Dangers of policies that focus too narrowly on

- just 1 or 2 channels
- short-term and more measurable effects

Key issue is not so much whether the benefits are there but how best to organise the national innovation system to make the most effective use of them

Conclusions

Science and technology of vital and growing importance for economic and social development

Public funding of research essential but comes with ‘strings’ – governments want to assess impact

No simple model possible of nature of economic and social impact of research

Major conceptual and methodological problems in attempts to measure impact of research

Extensive literature points to substantial benefits, although vary widely across sectors

Conclusions (cont.)

Benefits flow through various ‘exploitation channels’ so impact comes in variety of forms

Some of these forms less amenable to measurement

Dangers of policies that focus too narrowly on just one or two of the exploitation channels (e.g. the more easily measurable ones)

Key issue is not so much whether the benefits are there but how best to organise the national innovation system to make the most effective use of them

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