



Institute for Technology and Regional Policy

Evaluating the Economic Impact of Basic Research

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Wolfgang Polt / JOANNEUM RESEARCH

wolfgang.polt@joanneum.at

THE question

- Why do we want to know the economic return of basic research – if the primary motivation for basic research is not (immediate) economic return?
- Because we would have to ask ourselves ‘are we spending enough on basic research’ (NELSON 1959) - the perennial question -, because society as a whole has to allocate resources to alternative goals / ends.

... and some strong views on the economic benefits of basic research....

- '...it can be seen that NEARLY ALL technologies, products and achievements which have led to economic and commercial success and/or concrete improvements to the quality of life ARE BASED ON BASIC RESEARCH...' (EU COM 2003)
- In a US-EU comparison, the same paper asserts that 'the gap is generally wider in fields of BASIC RESEARCH where an increase in knowledge is likely to have a PARTICULARLY MARKED EFFECT ON COMPETITIVENESS'

Some strong statements on basic research....

or earlier (those were the times...):

**“THE RETURNS [OF SCIENCE] ARE
SO LARGE THAT IT IS HARDLY
NECESSARY TO JUSTIFY OR
EVALUATE THE INVESTMENT”**

**(NSF, BASIC RESEARCH – A NATIONAL
RESOURCE, 1957)**

... and about the difficulties in identifying

- ‘The difficulties in precisely identifying and measuring the benefits of basic research are hard to exaggerate...’ (ROSENBERG 1990)
- Economic impacts of basic research: too difficult to measure, but certainly so large that they need no justification ?
- Here, the focus will be on the question: can economic valuation techniques help in the investment decision on how much to spend in basic R&D? Examples of the scope and the limits of some approaches....

Measuring the return on R&D – a short list of studies

Impact of R-D on output and productivity growth	Impact on rate of return to investment		
Coe and Helpman (1995)	Bernstein (1988, 1989)	Jaffe (1986)	Schankerman-Nadiri (1986)
Cuneo-Mairesse (1984)	Bernstein and Nadiri (1988, 1989a, 1989b, 1991)	Lichtenberg-Seigel (1991)	Scherer (1982, 1984)
Englander-Mittelstadt (1988)	Clarck-Griliches (1984)	Link (1978, 1981, 1983)	
Griliches (1980a, 1980b, 1986)	Englander-Mittelstadt (1988)	Mansfield (1977, 1980)	Sterlacchini (1989)
Lichtenberg (1992)	Evenson (1968)	Minasian (1962, 1969)	Suzuki (1993)
Mansfield (1988)	Evenson et al. (1979)	Möhnen-Nadiri-Prucha (1986)	Sveikauskas (1981)
Mairesse-Cuneo (1985)	Goto and Suzuki (1989)	Nadiri (1993)	Terleckyj (1974, 1980)
Mairesse-Hall (1996)	Globerman (1972)	Nadiri-Prucha (1990)	Wolff-Nadiri (1993)
Nadiri (1980)	Griliches (1958, 1973, 1980a, 1980b, 1986)	Odagiri (1983, 1985)	
Nadiri-Prucha (1990)	Griliches-Lichtenberg (1984a, 1984b)	O'Mahony (1992)	
Verspagen (1995)	Griliches-Mairesse (1983, 1984, 1986, 1990)	O'Mahony-Wagner (1996)	
	Hall -Mairesse (1995)		
	Hanel (1988)	Schankerman (1981)	

Source: Godin and Doré



Measuring the return on R&D

Studies differ widely in scope and approach, even in concepts:

- University(-based) research
- Public research
- Strategic research
- Publicly funded research
- ...very few studies purely on 'basic research'

Approaches to measuring the economic impact of R&D

- **Macro** (aggregate impact on productivity / GDP)
 - Effects of R&D on productivity and growth, see e.g. GUELLEC and VAN POTTELSBERGHE (2001, 2004)
- **Meso** (on the level of industries, technologies or programmes)
 - MANSFIELD (1977 ff)
 - BEISE and STAHL (1998) and FIER (2004)
- **Micro** (on the level of individual R&D projects, enterprises or institutions)
 - See e.g. FELLER and RUEGG (2003) for an overview of results from the ATP programmes

Approaches to measuring the impact of R&D

— Ex-post

- Projects TRACES (UK) and HINDSIGHT (US DoD), for the latter see ISENSEN 1967 and CHAIT et al 2006
- E.g. BETA (1997) BESSETTE (2003), ATP (1997ff) etc.

— Ex-ante

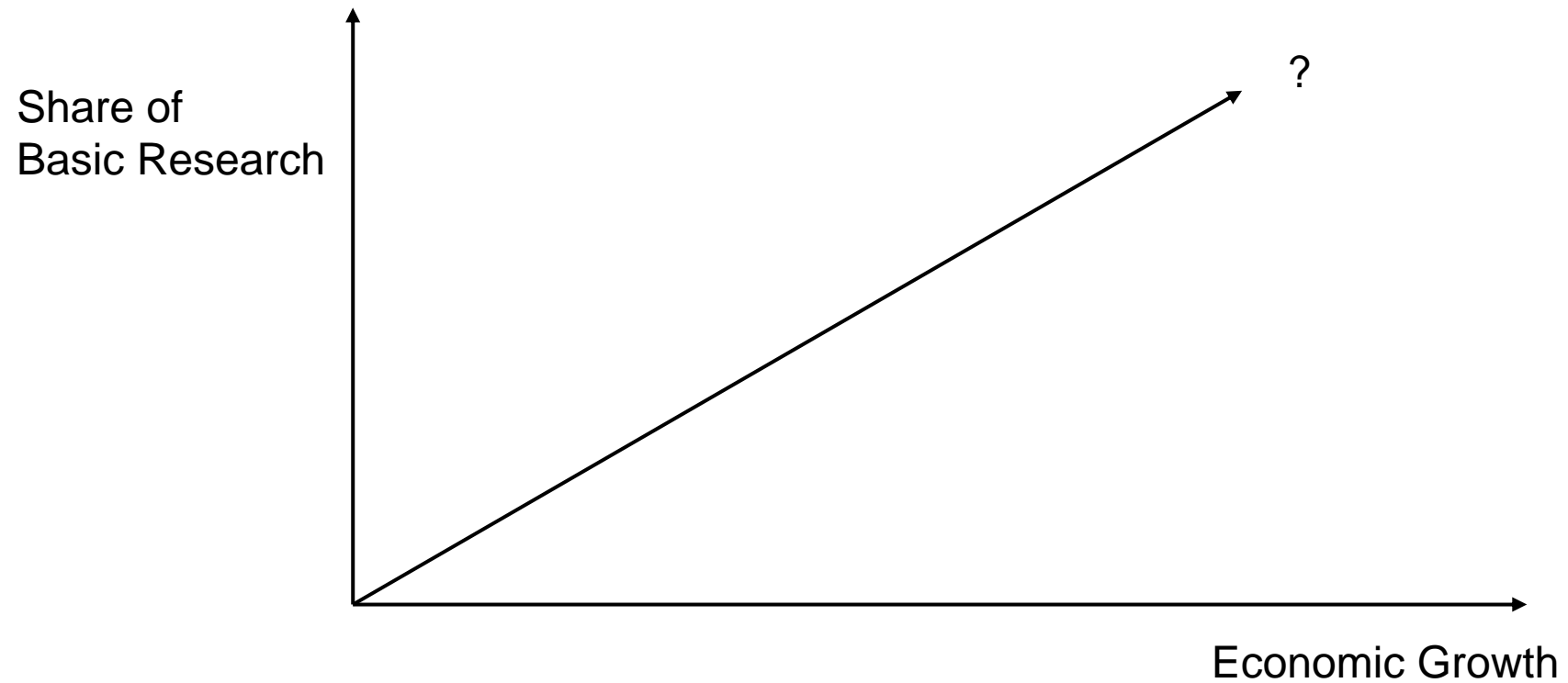
- RESEARCH TRIANGLE INSTITUTE (1998)
- LINK (1999 ff)
- VONORTAS (2006)



Example 1: a (very!) simple macro view

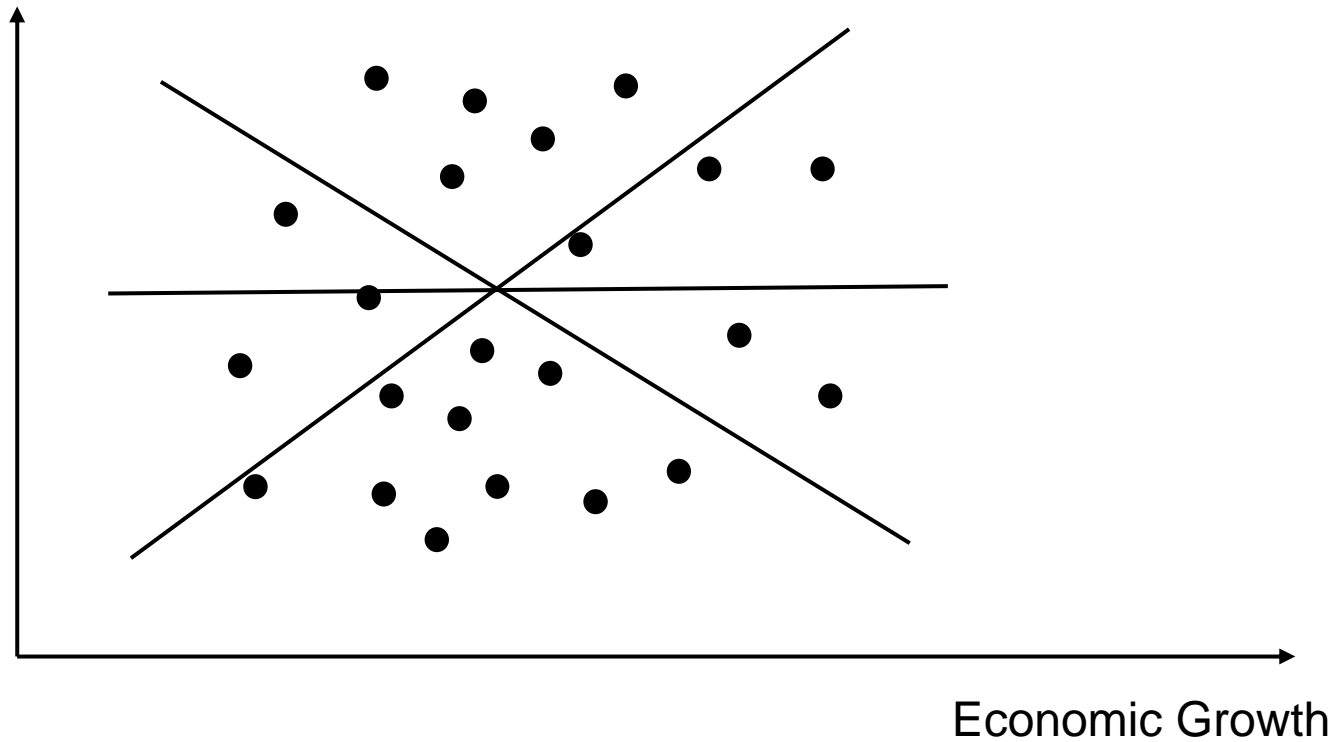
- ... a perfectly legitimate question ... which should not be raised in the way it is raised very often:
- „What is the relation between basic research and economic growth...??“
- You, economist ! Can't you provide a correlation ?

The simple economics of basic research and economic growth

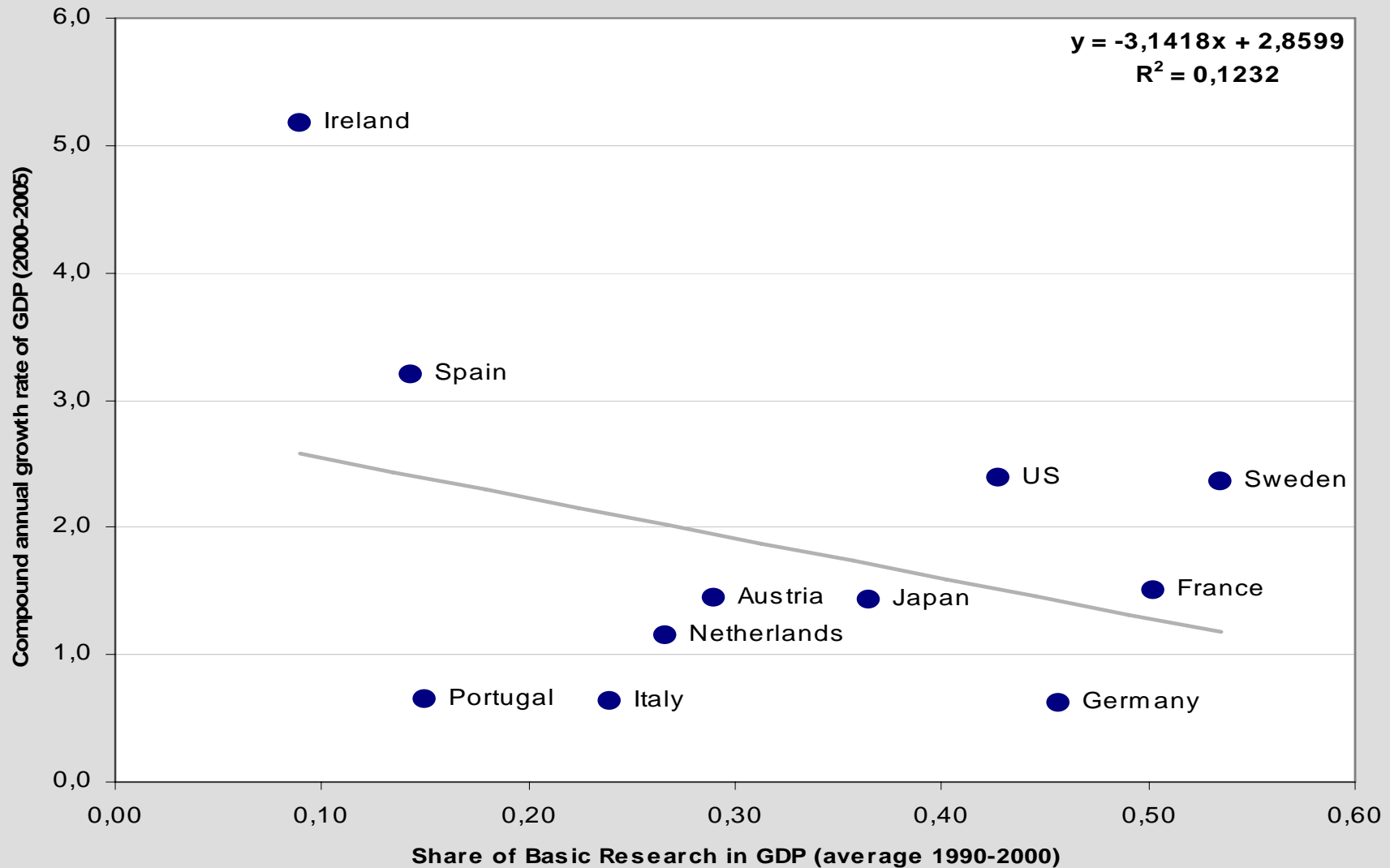


The simple economics of basic research and economic growth

Share of
Basic Research

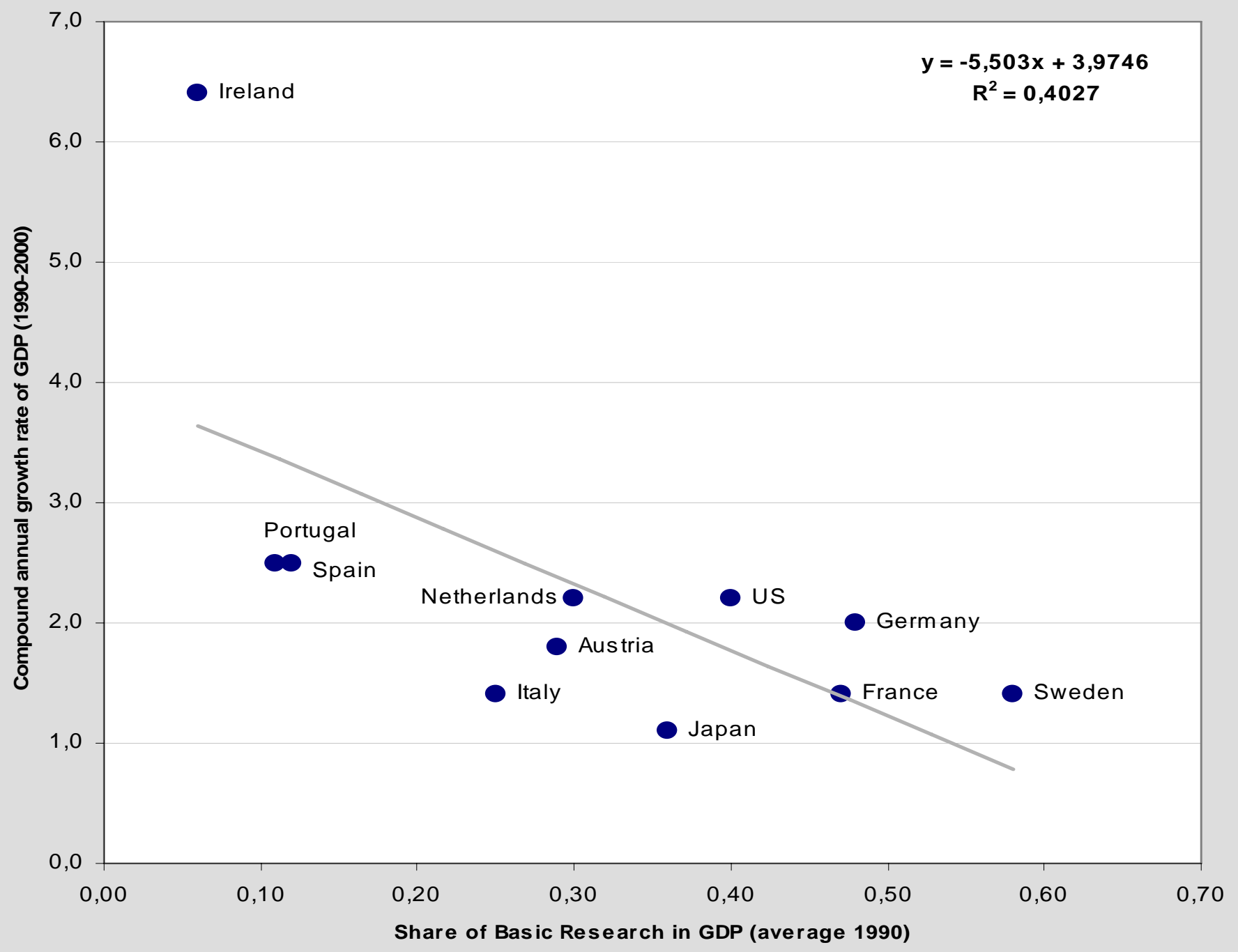


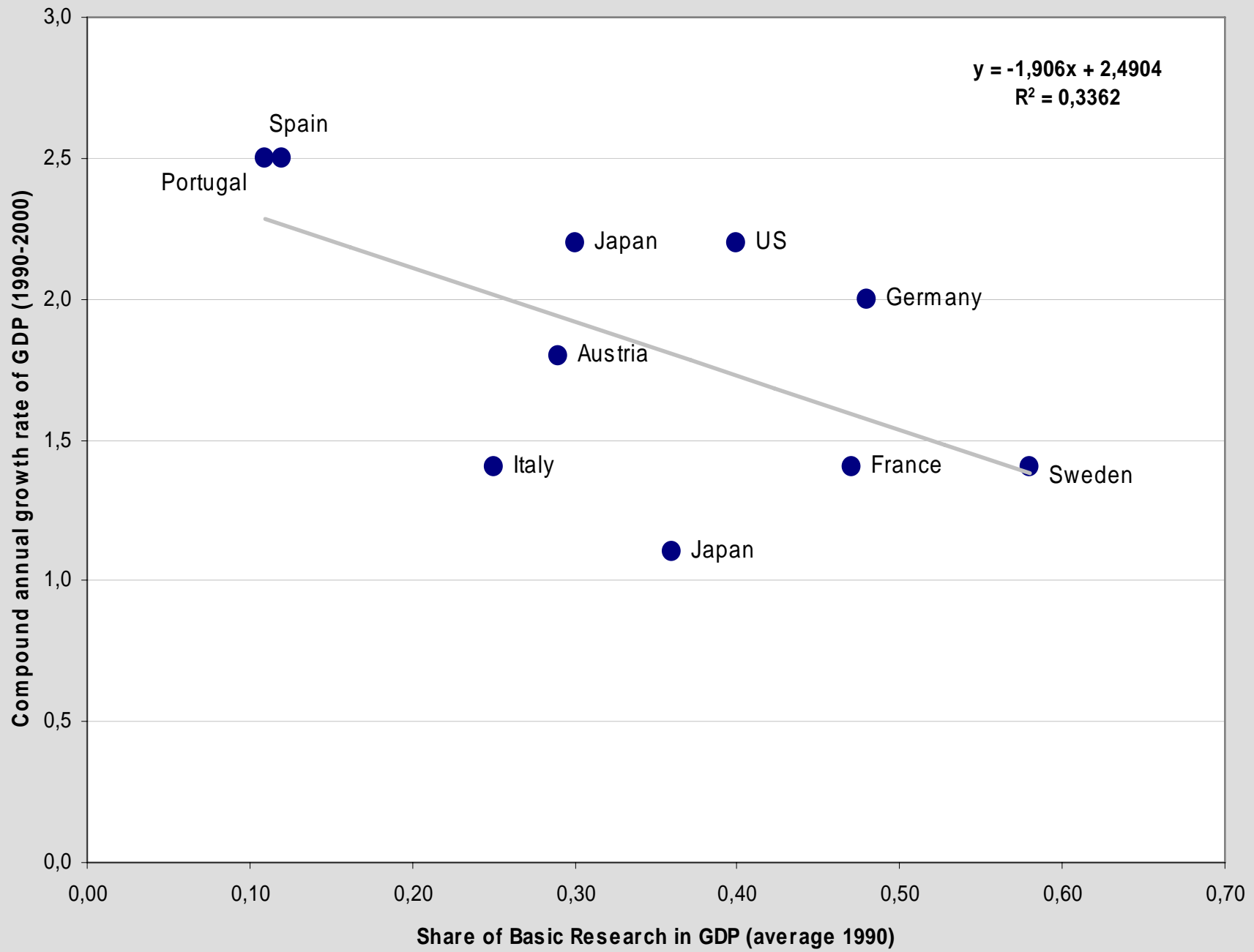
Basic research and economic growth – another spurious correlation



Source: own calculations, based on MSTI 2006

Wolfgang Polt, Science Impact, May 2007





... a warning to the user...

- Inappropriate use of spurious correlations can damage your science and technology policy !
- The task is: getting the question right !

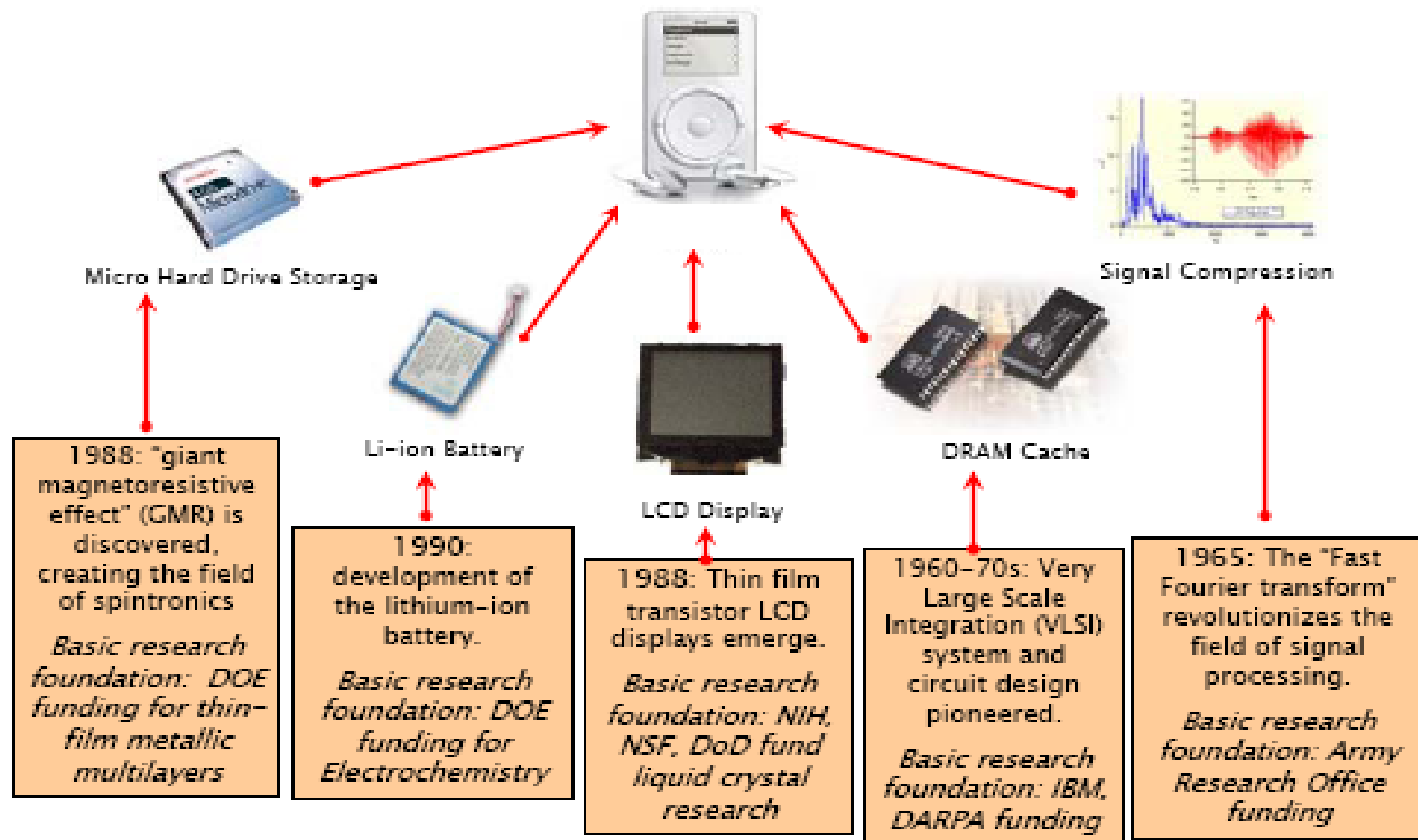
**Some (more comforting, but still
not completely satisfactory !)
Examples from the
meso and micro view**



A case study approach: tracking 'critical technological events'

IMPACT OF BASIC RESEARCH ON INNOVATION

Source: American Competitiveness Initiative, Feb. 2006



Case study approaches:

- Scope: can provide insights into the channels and actors in translating science into innovation, illustrative for the various inputs (basic) research can provide
- Limits: mostly qualitative, hardly a guide for concrete future selection of topics and projects



A case study approach: Cost-Benefit Analysis (CBA) of R&D projects



CBA approaches:

- short-term ex-post
- Long-term ex-post
- Ex-ante



CBA metrics for measuring the economic return of R&D – ex-post short term view

$$\text{Simple ROI} = \frac{R}{100} = \left[\frac{O - (C - I)}{I} \right] - 1$$

$$\frac{R}{100} = \left[\frac{(O = \text{jobs} + \text{sales} + \text{tax revenues} + \text{secondary impact} + \text{grants}) - (C - I)}{I(\text{public, private, university})} \right] - 1$$

“THE RESULTING ROI ALLOWS RANKING OF THESE INVESTMENTS” (BESSETTE, 2003)

„Stylized results‘ from short-term ex-post CBA

Project	ROI
Company A	140%
Company B	(-17%)
Company C	33%
University D	1,600%

..clearly these differences are a guide for public investment ?

Russell W. Bessette

*Executive Director, New York State Office of Science,
Technology and Academic Research*

..and what to do with the results...

- „...In our example, a State agency monitoring economic development should closely monitor Project B's evolution and its request for future financial support..." (BESSETTE, 2003)
- NO TIME DIMENSION ! (discounting)
- But for how long should they monitor to see the emergence of economic effects ?
- → example of MITI/METI Medical Technology Programme !

CBA for measuring the economic return of R&D – ex post long term view

Marginal internal rates of return for US public investment in sector-specific agricultural research, extension and education, 1950-82

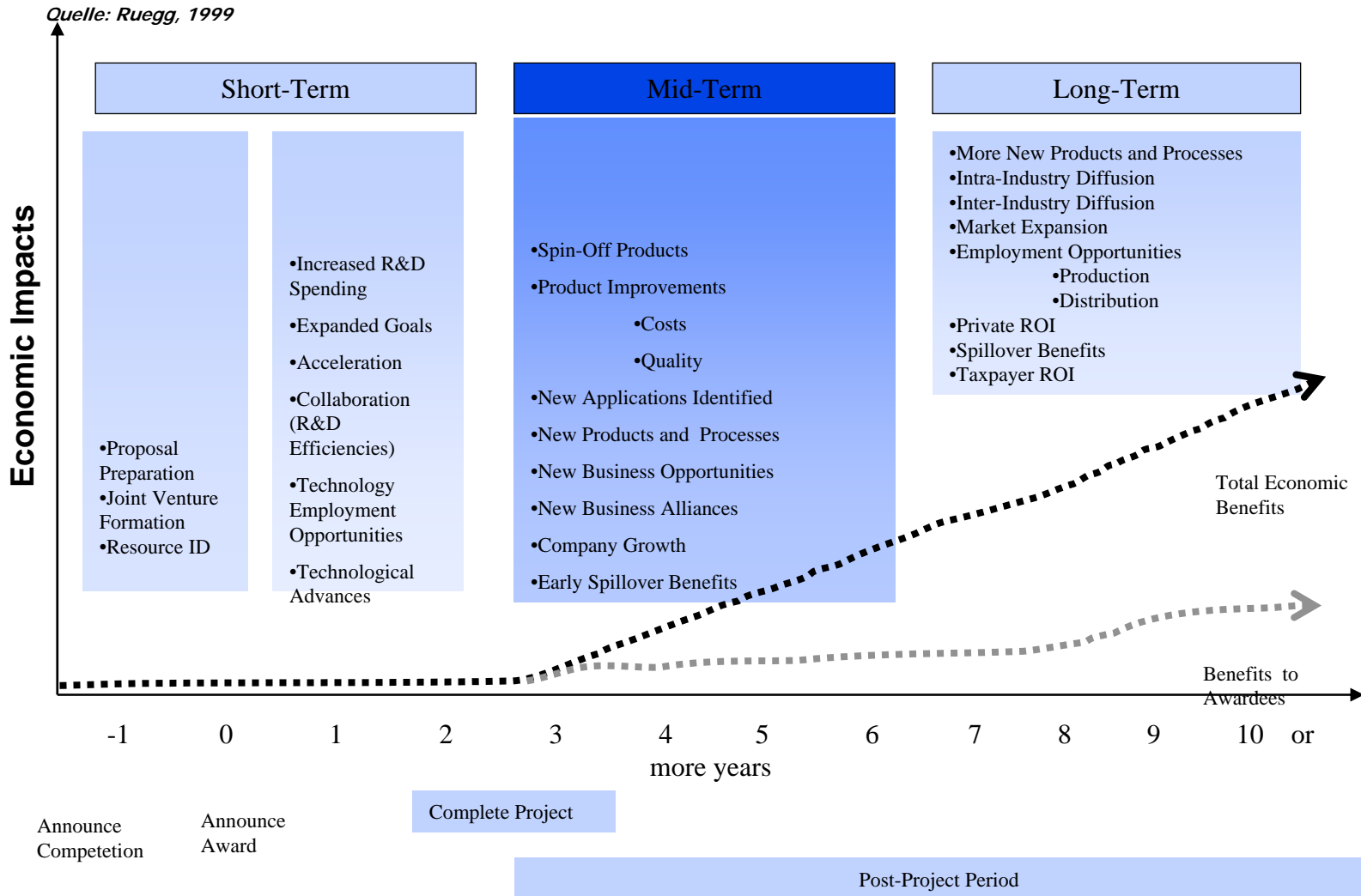
	<i>Crop Sector</i>	<i>Livestock Sector</i>	<i>Aggregate</i>
All research	47	<0	40,6
Pre-technology research	62,2	83,2	73,5
Extension	40,1	<0	20,1
Farmer's schooling	22	19	40

Source: Huffman and Evenson (1993)

..and what to do with the results...

- More advanced through bringing in the time dimension
- Can demonstrate (partial) overinvestment and the different rates of return to different types of publicly funded R&D
- But no guide for future investments, because the projects are different each time....

Economic effects of R&D over time



CBA metrics for measuring the economic return of R&D – ex ante

Internal rate of return =

$$IRR = \sum_{t=0}^n \frac{B_t - C_t}{(1+r)^t} = 0$$

Benefit/Cost ratio =

$$\frac{B}{C} = \frac{\sum_{t=0}^n \frac{B_t}{(1+r)^t}}{\sum_{t=0}^n \frac{C_t}{(1+r)^t}}$$

Social Rates of Return for ATP funded tissue engineering research

ATP PROJECT	EXPECTED SOCIAL RETURN ON TOTAL INVESTMENT		EXPECTED SOCIAL RETURN ON PUBLIC (ATP) INVESTMENT	
	NPV (1996 \$ millions)	IRR (percent)	NPV (1996 \$ millions)	IRR (percent)
Stem Cell Expansion	134	20	47	21
Biopolymers for Tissue Repair*	98	51	98	51
Living Implantable Microreactors	74,518	149	17,750	148
Proliferated Human Islets	2,252	36	1,297	34
Biomaterials for Clinical Prosthesis	32,855	118	15,058	128
Gene Therapy Applications	2,411	106	945	111
Universal Donor Organs	2,838	91	783	92
Composite Rate for All Projects**	109,229	115	34,258	116

..and what to do with the results...

...served as justification of the investment, as (expected) SRR at least equaled the whole of the funding of ATP in this year

Evaluating the economic impact of basic research – scope and limits of current approaches

Scope

- ...we have come some way since NELSON (1959)
 - Departure from the linear model (V.BUSH 1945)
 - Beyond spill-over: interaction in knowledge production (GIBBONS et al 1994)
 - considerable advance in measuring the impact of applied R&D
- but: only few studies devoted to quantitatively identifying the economic impact of basic research, and these encountered the following
- Thus: yes, we can say something about the economic effects of basic research – but can we say what is warranted by policy-makers (and sometimes by funding agencies?)

Evaluating the economic impact of basic research – scope and limits of current approaches

Limits

- Delineation of basic research:
'there is no strict, unanimously accepted definition of what constitutes basic research'...(EU 2003, 5)
- Measurement of costs (more tricky in basic research than for usual investment projects)
- Variety of outputs
- Time lags of impacts
- Spill-overs to other fields/industries (where the impact might not even be recognized)
- in short: **ATTRIBUTION PROBLEM**
- and, (especially for ex-ante): **PROJECT FALLACY**

Evaluating the economic impact of basic research - a policy and a research agenda

The policy agenda

- From New Public Management:
 - increasing output orientation: GPRA 1993
 - Increasing pressure to demonstrate ‚bang for the buck‘
- Or(and) to the competition about resources
 - example in case: American Competitiveness Initiative (ACI, ‚Marburger Initiative‘)
- To ‚Managing Innovation Systems‘ (OECD)
 - Creating incentives for Mode2 knowledge production
 - Defining programmes in the ‚Pasteur quadrant‘

Evaluating the economic impact of basic research - a policy and a research agenda

The research agenda

- Surely, more research (on basic research) is needed. Or is it? („CBA when we don't know the costs and we don't know the benefits?“)
- Beware of (and fence off!) overly simplistic approaches to quantifying and ranking of research areas / technologies / projects !
- Ex-post identification of benefits (e.g. by CBA) can be undertaken, but can only serve as an illustration of the potentially beneficial role and can hardly serve as an ‚investors guide‘.

Evaluating the economic impact of basic research - a policy and a research agenda

The research agenda

- The most important results from CBA are the qualitative insights which shed light on the various spill-overs to different actors in translating results of basic R&D into innovations
- „...the precise alloaction [between basic and applied research] is not important, as long as it is sufficiently diversified. Rather than attempting to refine the allocations, energy and resources may be more productively focused on ways to improve links within the research system.“
(PANNELL, 1999)



...but for those who are not satisfied with this overly complex answer of limited political clarity, there is always the fall-back version of the answer to the ultimate question ! →

...and the answer to the final question is of course...

$$\phi IRR BR_{t_0 \rightarrow \infty} = 42$$

(average Internal Rate of Return for Basic Research from now to eternity)

(see Douglas Adams: „The Answer to Life, the Universe, and Everything “, http://en.wikipedia.org/wiki/The_Answer_to_life%2C_the_UNiverse_and_Everything)