Public innovation policies and tools for strengthening National Innovation Systems – Challenges and best practices

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Outline

- Rationale for public innovation policies
  - Public good characteristics of knowledge production leading to the appropriaibility problem
- Scope of innovation policy instruments
- A taxonomy of policy instruments
  - Three types of innovation policy instruments
- Focus on two financial instruments: research grants and tax incentives
- Conditions under which the instruments are effective

Rationale for innovation policies

- Knowledge has public good characteristics: (i) non-rivalrous- several individuals can consume the same good without diminishing its value; and (ii) non-excludable- an individual cannot be prevented from consuming the good.
- Given the public good nature, there can be under investments in knowledge production.

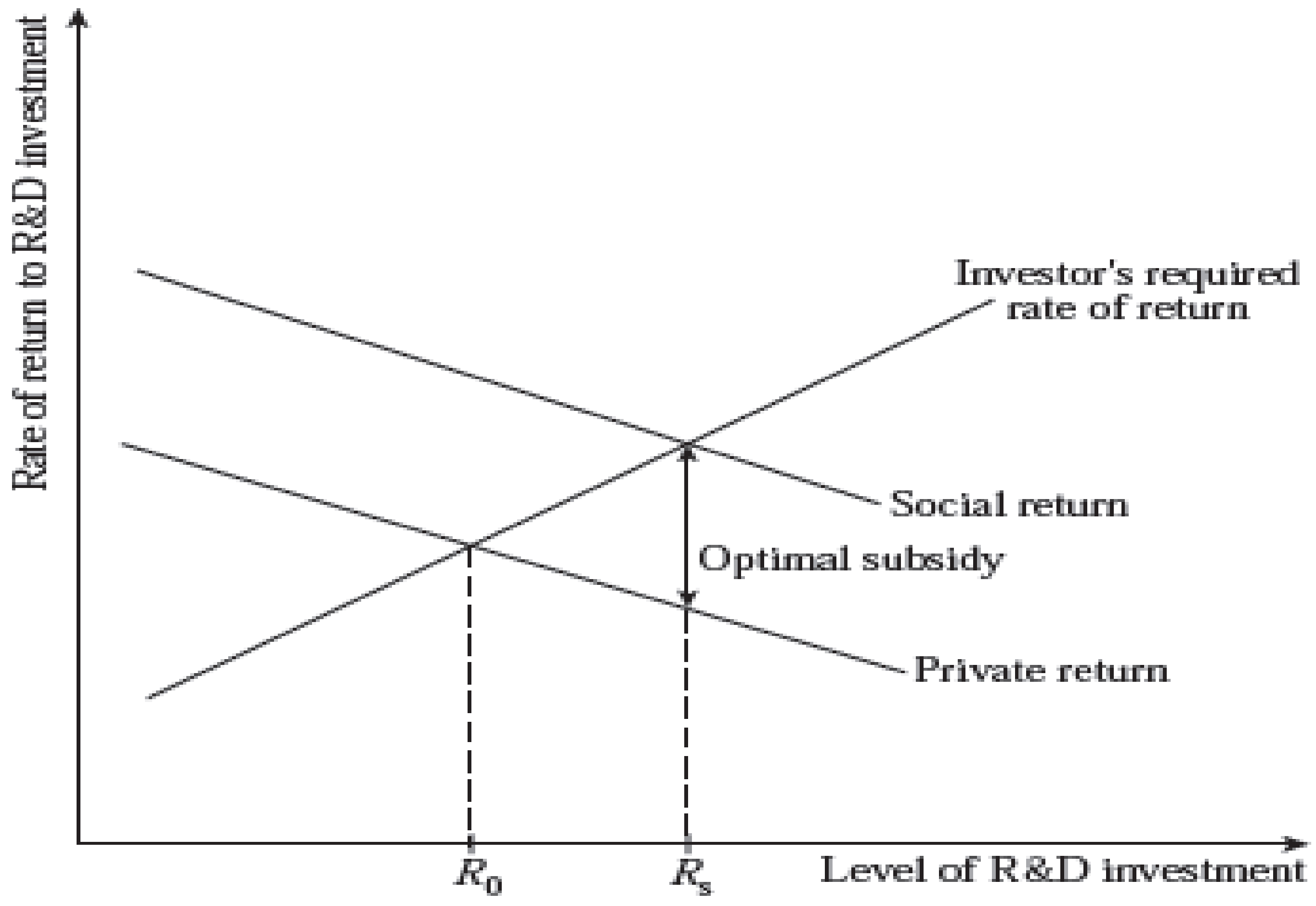
Market Failure in Knowledge Production

Market Failure 1

- This is a situation where the business enterprises fail to finance its own intramural R&D due to its inability to appropriate the full return to its own research efforts. This is because knowledge has public good characteristics, namely: (i) it is non-rivalrous- several individuals can consume knowledge without diminishing its value; and (ii) it is non-excludable- an individual cannot be prevented from consuming knowledge.

- Given the public good nature, there can be under investments in knowledge production. A more formal way of stating this possibility of underinvestment is by invoking the appropriaibility problem. The creator of knowledge fails to appropriate the full returns from her own research because, despite patent protection knowledge is prone to leaking

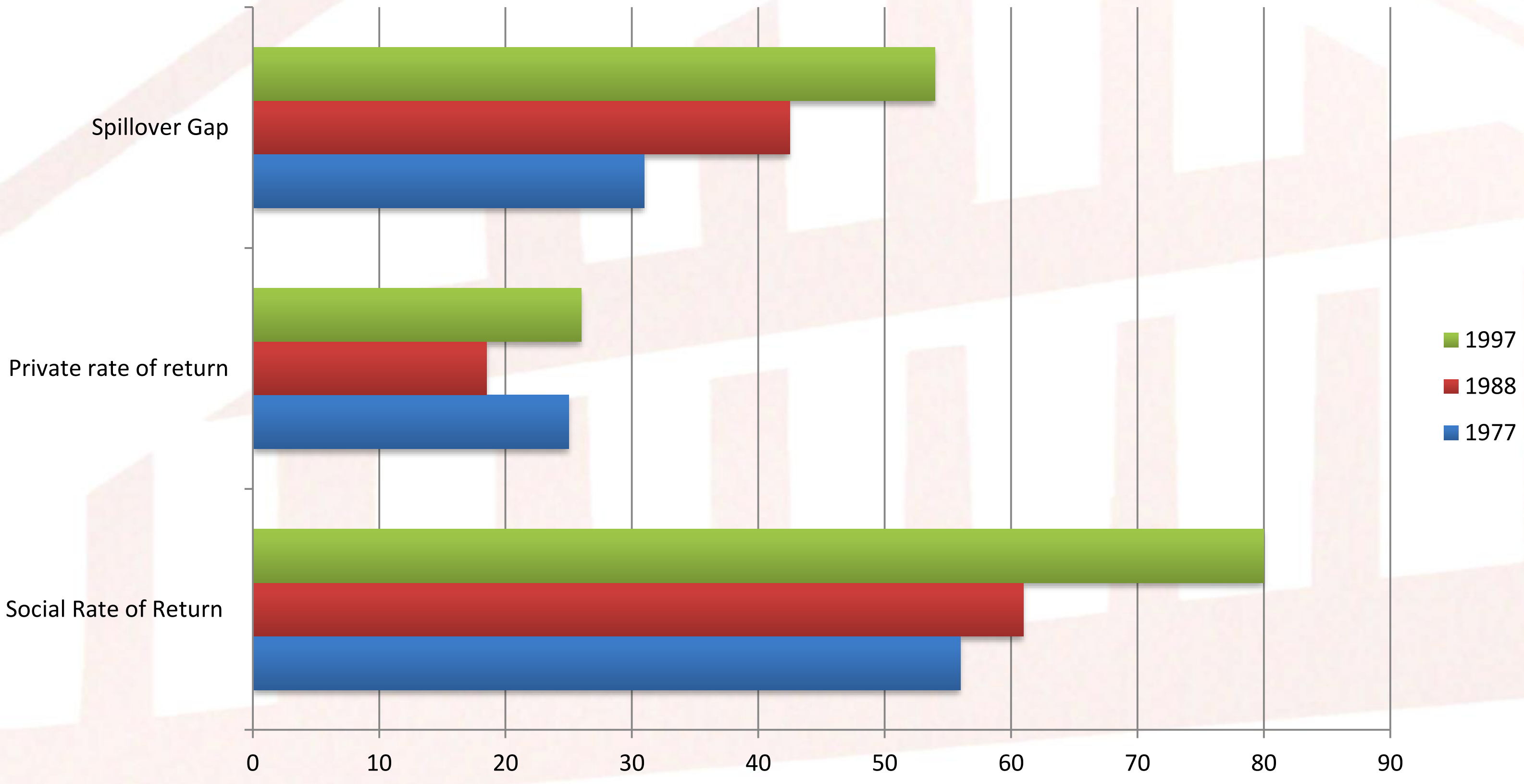
Diagrammatic representation of market failure



Explanation of the diagram

- Without any subsidy, private investors equate their expected private return to their required rate of return (the rate that covers the cost of investment funds) and the result is a level of investment of **R**0.
- The socially optimal level of R&D investment is where the social return is equated to the opportunity cost of funds. The social return is higher due to the positive externalities of R&D. With a subsidy to R&D the government effectively raises the private return to equal the social return and so private investors now choose the socially preferred higher level of investment **R**s.

Spillover Gap



Market Failure in Knowledge Production

Market Failure 2

- Output of R&D is an uncertain activity. When something is uncertain, you cannot even attach probability to potential outcomes.
- Hence the conventional capital market (whether debt or equity market) eschews such R&D projects. Since it is difficult to fund R&D, actual level is less than the optimum level. This is the second market failure.
- The policy response to this is the creation of specialized financial institutions such as venture capital and conditional loans- loans, which carry a rate of interest less than the market rate.

Three other reasons for public support for business R&D

- Crucial investment for the long run growth of economies
- Maintaining jobs especially during periods of crises
- Contributing to national competitiveness

The two types of market failures and the policy response to overcome it

Policy instruments to deal with the two market failures

First market failure

- Have a strong IPR regime- preventing leakage of ideas
- Provide a subsidy to firms in the form of research grants and tax subsidies

Second market failure

- Have specialised financial instruments which is designed to finance innovations
- Examples of these are conditional loans, but the most common is venture capital

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Three types of policy instruments

- **Type 1:** Public funded innovation carried out by academic institutions and public research organizations,

- **Type 2**: Governments can fund research undertaken by private firms-notably through public procurement, research subsidies, soft loans, R&D tax credits and innovation prizes

- **Type 3**: The IP system is the one mechanism that promotes privately executed R&D which is financed through the marketplace rather than government revenues.

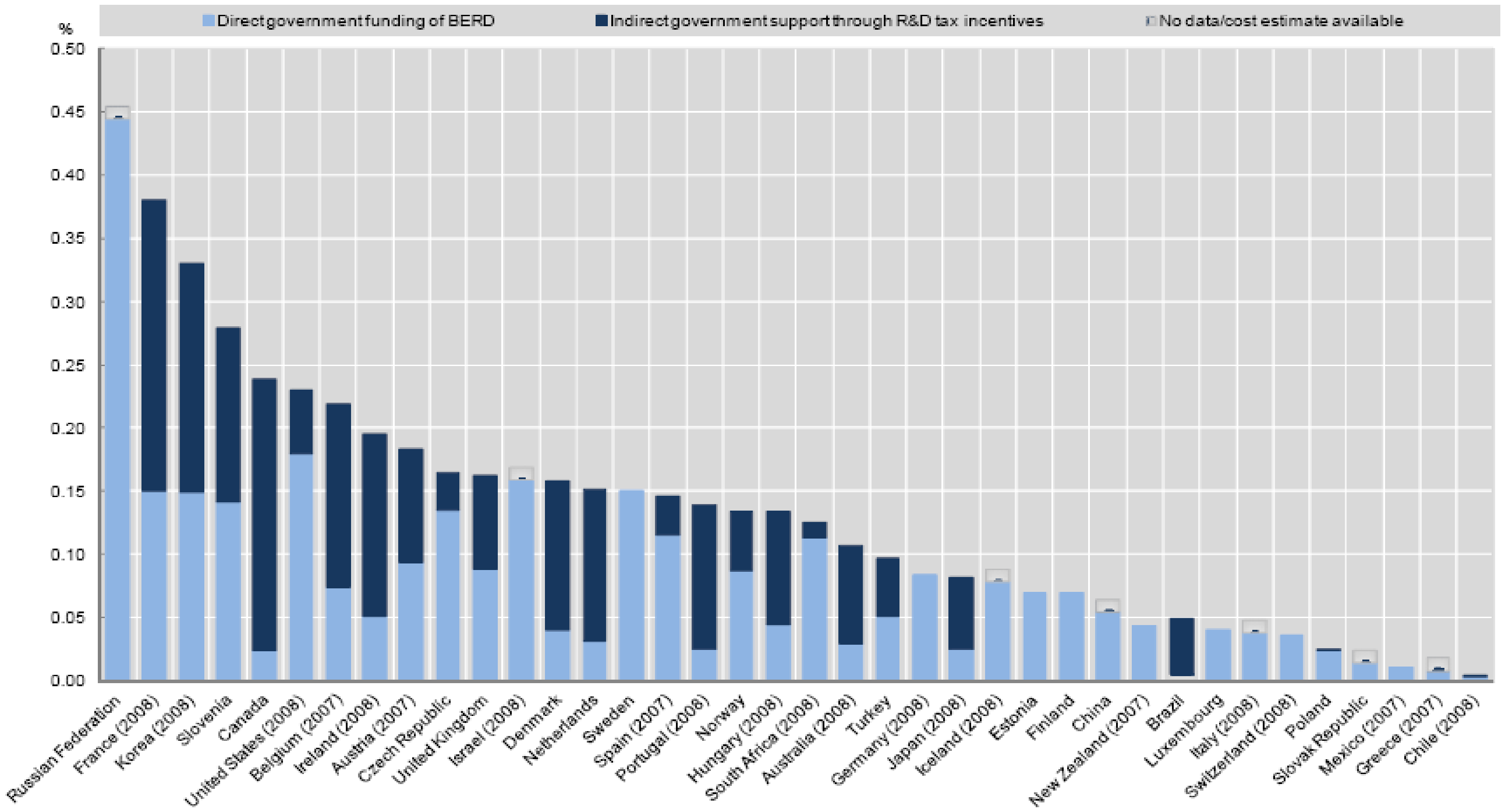
Complementarity between policy instruments

- Various instruments of innovation policy can be complementary. For instance, academic research sometimes results in patents and subsequent licensing for commercial development. Similarly government support of privately undertaken research may result in IP ownership.

Two major subsidy instruments for spurring innovation at the firm level

- R&D tax incentives- indirect
- Research Grants- direct

Direct and Indirect government funding of business R&D and tax incentives for R&D, 2009 (as a percentage of R&D)



First instrument:
R&D Tax Incentives

- How popular it is ?: diffusion across countries
- Design Issues: Volume vs Incremental
- Measuring the size of this subsidy
- Genorosity and effectiveness

Diffusion of R&D Tax Incentives across the world

- As of today (2012), 20 OECD countries have tax incentives- up from 12 in 1995
- Germany and Finland do not have R&D tax incentives, but now they are considering its introduction.

- Many developing countries, including that of India, provides R&D tax subsidies

Design Issues: R&D Tax Incentive

- It manifests itself in two forms: (i) level or volume; (ii) incremental

- A level or volume scheme provides the tax relief on the total amount of R&D (although there may be upper limits)

Design issues…

- An incremental system gives the tax relief on increases in R&D over a base figure. The base figure can be calculated in various ways, such as average R&D expenditure over the last three years, but its central objective is to increase R&D spending.
- A level or volume R&D tax incentive is more straightforward to implement, but does give tax relief on R&D that would have been conducted any way.

- An incremental scheme avoids this problem but depending on exactly how the base figure is calculated and updated- can create some quite complex, and even negative, incentives for firms.
- As an indication of this if the base figure is simply last year's R&D, a firm should realize that increasing R&D now will reduce tax relief in the future (since the base year spending will rise).
- These issues mean that many countries opt for a level system or possibly a combination of both.

Level or Volume vs Incremental across countries

Design of the R&D tax incentive scheme	*Volume base R&D tax credit*	Australia, Canada, France, Norway, Brazil, China, India
	Incremental R&D tax credit	United States
	Hybrid system of a volume and an incremental credit	Japan, Korea, Portugal, Spain
	R&D tax allowance	Denmark, Czech Republic, Austria, Hungary, UK
Payroll withholding tax credit for R&D wages		Belgium, Hungary, Netherlands, Spain
More generous R&D tax incentives for SMEs		Canada, Australia, Japan, United Kingdom, Hungary, Korea, Norway
Targeting	*Special for energy*	United States
	Special for collaboration	Italy, Hungary, Japan, Norway
	Special for new claimants	France
	Special for young firms and start-ups	France, Netherlands, Korea
Ceilings on amounts that can be claimed		Italy, Japan, United States, Austria, Netherlands
Income based R&D tax incentives		Belgium, Netherlands, Spain
No R&D tax incentives		Estonia, Finland, Germany, Luxembourg, Mexico, New Zealand, Sweden, Switzerland

Note: R&D tax allowances are tax concessions up to a certain percentage of the R&D expenditure and can be used to offset taxable income; R&D tax credits reduce the actual amount of tax that must be paid.

Which one is better? Level-based or Incremental-based ?

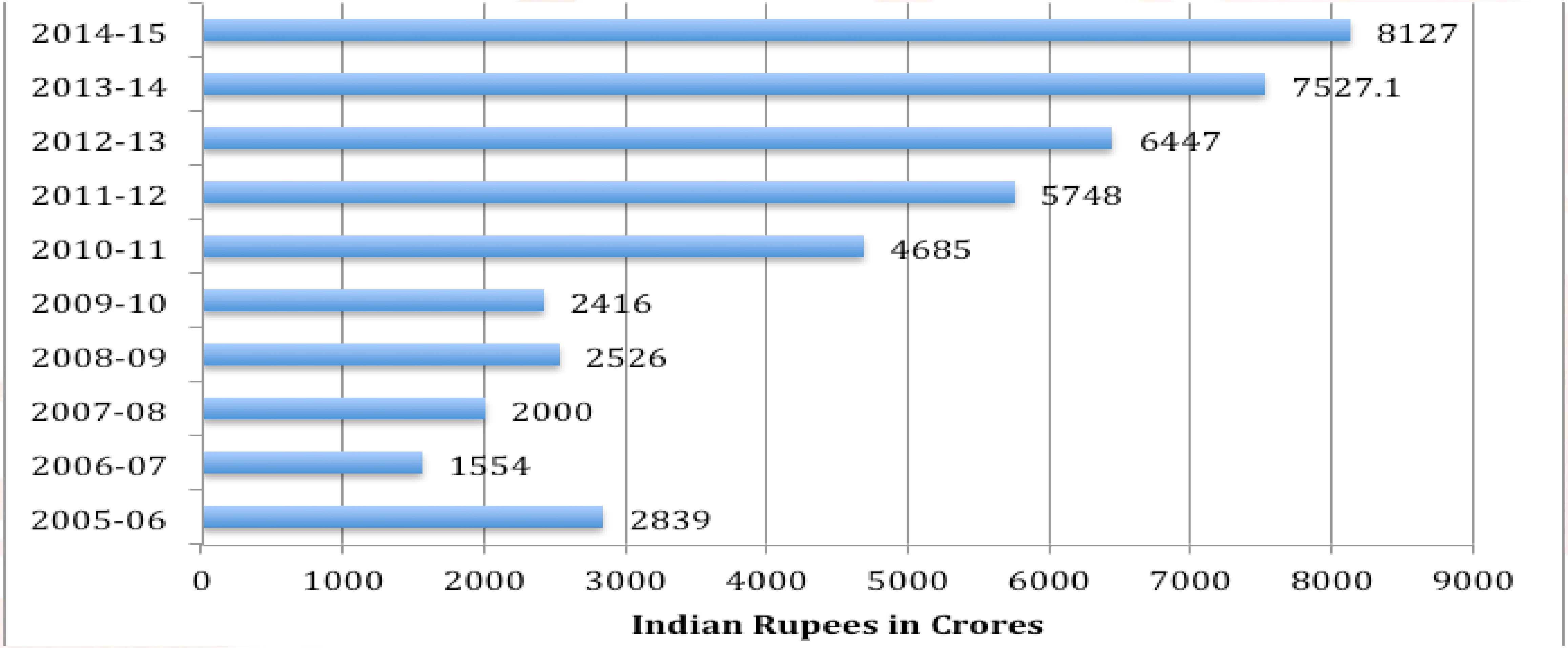
- Incremental tax credits are more efficient for the government (they minimises the amount of subsidized R&D that would have been undertaken even in the absence of support), however, they are also more complex to implement
- Level-based schemes are straightforward, less subject to fluctuations but costlier and tend to finance larger firms
- The design of schemes(incremental or volume) depends on policy objectives but also the tax base and capacity constraints (number of R&D staff)
- Generally, most countries are moving to volume-based incentives.

How does one measure the extent of R&D tax incentives in an economy ?

- There is no actual flow of cash from the government to business enterprise
- So the amount of tax incentive given during year ‘t’ is the amount of tax foregone as a result of this tax incentive.
- Some countries do provide direct estimates of the amount of tax foregone as a result of tax incentives.

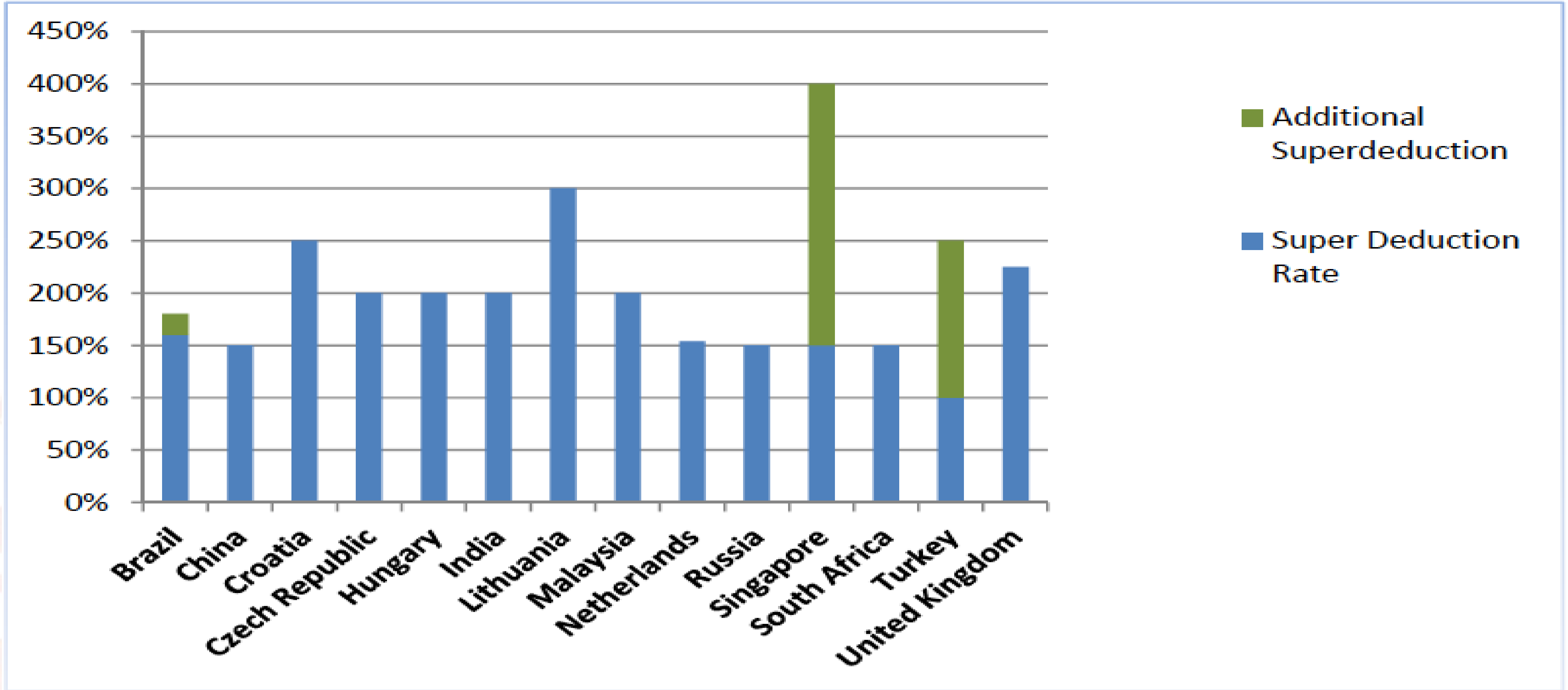
Size of R&D tax incentive in India

(equal to tax foregone by the scheme, Rs in Crores)



Generosity of R&D tax incentives

Countries having super deductions(c2014)



Measuring the generosity of R&D tax incentives

However generosity of a tax regime depends not just on the extent of tax deductions that are available but also on the corporate income tax rate.

So a summary measure or index called the B-index has been developed by analysts to measure generosity of a tax regime.

There are essentially two separate but related indices: (i) The B-Index; and (ii) The Tax subsidy Rate.

The B-index represents the before tax rate of return on one dollar of R&D investment, in present value terms.

For easy interpretation, the B Index is often reported as the 'tax subsidy ratio' (1-B Index), which is, simply put, the proportion of 1 dollar of R&D expenditure that is subsidized by tax incentives.

Negative tax subsidy ratio reflect cases where there are no tax incentives and capital assets employed in R&D cannot be written off in the year there were incurred, but rather are depreciated over time.

India has one of the lowest B-indices among the major R&D tax providing countries in the world.

Measuring generosity of R&D tax incentives

Generic:

B-index = (1-A)/(1-t)

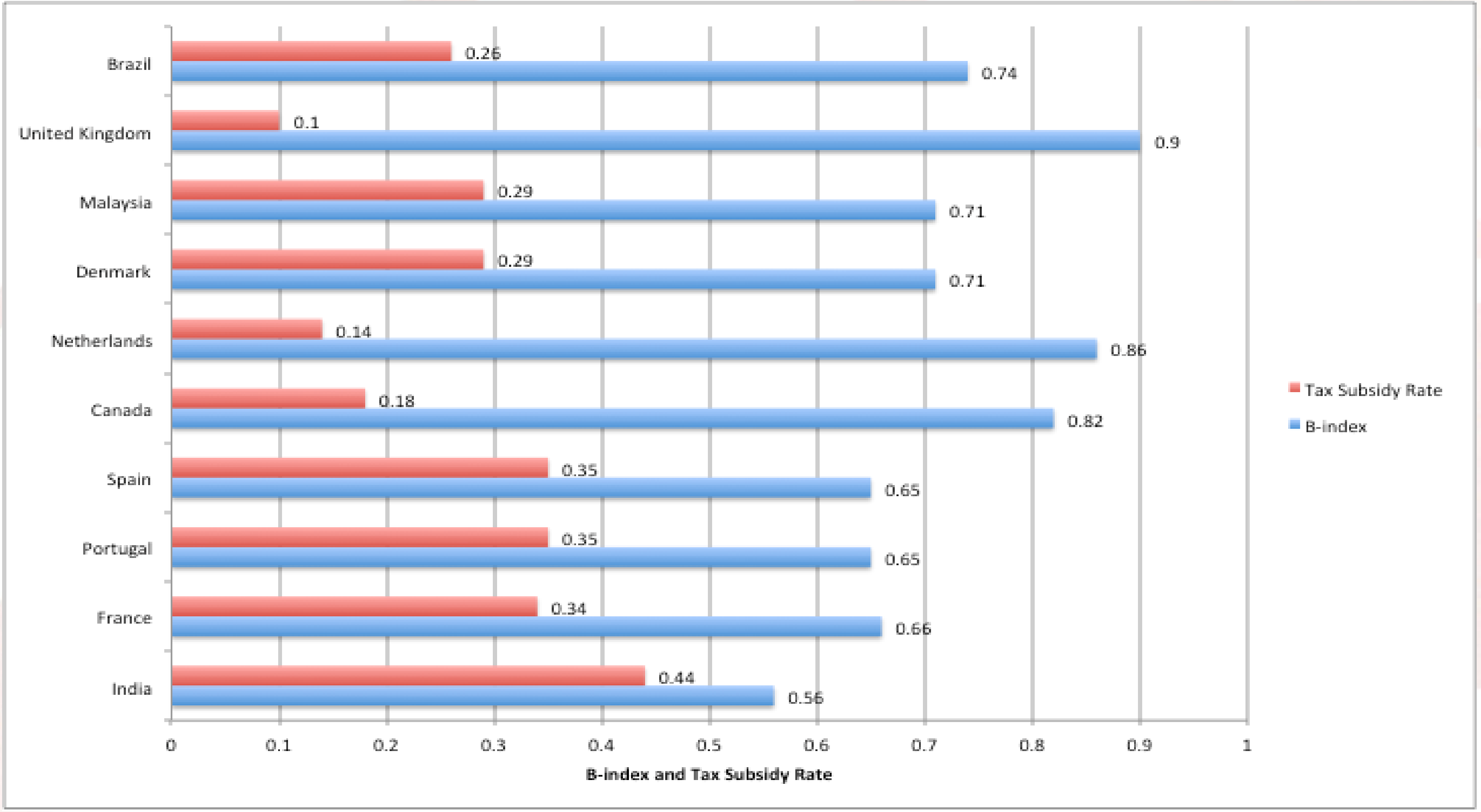
- A = the net present discounted value of depreciation allowances, tax credits and other R&D tax incentives available (i.e., after-tax cost)
- t = corporate income tax rate

A Country Example:

Canada:
B=(1 - xt - yzt - c(1-t))/(1-t)

France:
B=(1-xt – yzt -c)/(1-t)
where:
x = proportion of current R&D expense
y = proportion of capital R&D expense
z = PV of depreciation; c = tax credit; t = tax rate

India has world's most generous R&D tax regime



Evaluating the effectiveness of R&D tax incentives

- Diverse methods have been used
- For the purpose of policy assessment, firms cannot legally be excluded from a tax incentive to which they are entitled;
- This removes the possibility of evaluating R&D tax credits by constructing a control group using randomisation techniques.
- Evaluations have therefore been based on the following four approaches: surveys, quasi-natural- experiments; techniques using statistically constructed control groups, structural econometric modeling.

A two-way classification of the various studies measuring the effectiveness of tax incentives

(Please note that all these studies are in the context of developed countries, primarily that of the USA)

Methodology → **Level of Aggregation** ↓	**Survey Method**	**Econometric Techniques** **Price Elasticity of R&D With respect to a unit reduction in its cost**
Firm-level	Mansfield (1985)	Berger (1993) Hall (1993) Hines (1993) Swenson (1992) Tillinger (1991)
Industry-level		Baily and Lawrence (1987) Baily and Lawrence (1992) Mamuneas and Nadiri (1995)

Note: Dumagan (1995), General Accounting Office (1996), Office of Technology Assessment (1995), and Guenther (1998) provide critical summaries of the above.

Effectiveness of R&D tax incentives: What does the evidence tell us ?

- Evidence from OECD countries suggests that they do increase R&D
- Hall and Van Reenen (2000) review the evidence in detail and find that a rough guide is that a $ 1 increase in R&D occurs for every 1$ of tax relief.
- While it is useful to have knowledge about the cost of increasing R&D, ideally one would like more details about the societal benefits of the increased R&D
- Estimates of social rate of return to R&D suggest it is high

Measuring effectiveness of R&D tax incentives

- Diverse methods have been used for measuring effectiveness of R&D tax incentives.
- For the purpose of policy assessment, firms cannot legally be excluded from a tax incentive to which they are entitled. This removes the possibility of evaluating R&D tax credits by constructing a control group using *randomisation techniques*.
- Evaluations have therefore been based on the following four approaches: *surveys, quasi-natural- experiments; techniques using statistically constructed control groups, structural econometric modelling*.
- An econometric technique that is commonly used is to measure *the elasticity of R&D expenditure with respect a unit reduction in the cost of performing R&D*. If the coefficient of this elasticity is greater than unity, we say that the tax incentive has been effective in spurring additional amounts of R&D investment. On the contrary, if it is less than unity, the incentive has not been effective in increasing R&D expenditure proportionately more than the amount of tax foregone. Further if it is just equivalent to unity, the tax incentive has been neutral.

Elasticity of R&D expenditure = Proportionate change in R&D /Proportionate change in tax foregone

The Equations

For estimating the elasticity, we fitted the following functional form:

$$\ln R\&D_{it} = a + b_1 \ln Sales_{it} + b_2 tf2_{it} + b_3 \ln Export + u_{it}$$

Regression results

	Automotive	Chemicals (other than pharmaceuticals)	Electronics	Pharmaceuticals
ln tf2	-0.0045 (-0.017)	0.429** (3.08)	-0.138 (-0.59)	0.261 (1.37)
ln sales	1.244** (2.93)	0.470* (1.78)	0.816** (1.93)	0.394 (1.10)
ln exports	-0.0734 (-2.92)	-0.028 (0.246)	0.091 (0.624)	0.553* (1.89)
Constant	-6.262** (-2.48)	-1.126 (-0.703)	-4.26 (-1.55)	-2.01 (-1.08)
Sargan	30.12 (0.181)	26.03 (0.352)	23.34 (0.50)	27.67 (0.274)
AR (1)	-1.362 (0.173)	-2.516 (0.012)	-1.678 (0.093)	-1.944 (0.52)
AR (2)	-1.699 (0.089)	-0.326 (0.74)	-0.01 (0.992)	-0.266 (0.79)

Interpretation of the results

- The elasticity of R&D expenditure with respect to tax foregone as a result of the operation of the R&D tax incentive is less than unity for all the four industries, although it is significant only in the case of the chemicals industry.
- In two of the industries, namely in automotive and electronic industries the elasticity is even negative, although not significant. From this the reasonable interpretation that is possible is that tax incentive does not have any influence on R&D, excepting possibly in the chemicals industry where it has some influence although even in this case the change in R&D as a result of tax incentive is less than the amount of tax foregone.
- This lack of significant relationship between R&D and tax foregone can be rationalized by the fact that the tax subsidy covers only a very small percentage share (on an average 6 per cent) of R&D undertaken by the enterprises in the four broad industry groups.
- So our conclusion is that for tax incentive to be effective in raising R&D expenditures it must form a significant portion of R&D investments by an enterprise.
- It is not thus a determinant of R&D investments by enterprises. In fact this result corroborates the results of innovation surveys done in the context of such diverse countries such as Brazil and South Africa where innovating firm did not find government funds for innovation as an important instrument for financing their respective innovation efforts. In the Indian case even though 150 per cent of weighted deduction of R&D expenditure is allowed, the taxable income the firm has is not much. For firms to benefit from this specific incentive, their profit before tax has to be large.

Interpretation of the results (continued)

- Sales (a proxy for size) is found to be a more important determinant. This is in line with the Schumpeterian hypothesis that large sized firms are able to devote more investments on R&D;

- Surprisingly exports turned out to have positive and significant influence on R&D only in the case of the pharmaceutical industry. The other two industries are much more inward looking where the domestic market is more important than the export one; and

- In the case of the pharmaceutical industry much of the R&D is in the development of generic versions of known drugs which are then exported. So exports act as an important fillip.

Policy Conclusions

- We endeavoured to estimate the coefficient of elasticity of R&D with respect to tax foregone as result of this incentive scheme;
- The resulting exercise showed that R&D expenditure of the concerned industries was inelastic;
- We also found that the incentives did not form a significant portion of R&D;
- It is therefore not prudent to make any comments on the effectiveness of R&D tax incentives;
- But we see that the size of the firm does appear to be an important determinant of R&D , at least, in the case of some of the industries;
- Allowing firms to become larger and through that process of growth enabling them to become larger investors in R&D may be a better policy than providing them directly with subsidies.

Policy Conclusions (continued)

- Our hypothesis was that this was largely due to the quirks of methodology and the dataset used for such a computation.
- So until we have firm data on tax foregone due to the operation of this specific R&D scheme we are not in a position to draw very firm conclusions about its effectiveness.
- The only safe conclusion that this study allow us to draw is the fact that the government has targeted the right sort of industries for awarding this incentive scheme.

Critical factors to be borne in mind while introducing R&D tax incentives

- Firms might “re label” their outlays following the introduction of a tax incentive. They might re label some of their existing non R&D activities as R&D investment. This would lead to a spurious increase in measured R&D. The available evidence suggests that the incidence of this factor is relatively small, particularly in the long term;

- The introduction of an R&D tax incentive would likely cause an increase in the wages of scientists and engineers, due to the inelastic supply of such workers, at least in the short run. Part of the potential benefits of the R&D tax incentives are therefore “eroded” by an increase in the volume R&D performed;

- Finally, projects financed through R&D tax incentives might be those with the lowest marginal productivity. If there are decreasing marginal returns to R&D, the additional R&D induced by an R&D tax incentive might be less productive.

Research Grants

- Research grants are usually conceived as the best way of sharing in the risk of the innovator, as the grant amount is never paid back.

- Although in some cases when the new product or process is released as a result of the grant a royalty amounting to a percentage of the sales of the new product is paid back to the exchequer by the grantee.

- Grants are a direct way of promoting R&D and the outcomes are also easily measurable. Governments have used grants to develop strategic and high technologies where initial amounts required for the development of the new technology and the failure rates are very high that no business enterprise is willing to finance such innovations.

- Grants can also be used to enable business enterprises know how to do R&D.

- The major disadvantage of research grants is that it is very discretionary. Who gets how much is decided by the grant administrator and this can lead to situations of accumulative advantage and lobbying in securing grants.

Accumulative advantage and Matthew Effect

- Accumulative advantage is described as the process whereby the initial social status of a scientist influences their probability of obtaining a variety of forms of recognition. This leads to those who are well placed enjoying an initial advantage relative to less well-placed peers of equal ability. Once established in a favourable position a good reputation accrues further advantages disproportionately through the *Matthew Effect* such that on a cumulative basis over time the *rich get richer*.

- Lobbying is very common especially in developing countries where an unholy alliance of sorts is forged between business enterprises and the bureaucracy leading to unfair advantages.

- A still another disadvantage of grants is the fact that it is subject to annual budget cuts and so it becomes temporary and unstable.

What is Matthew Effect?

The term Matthew effect has been attributed to the sociologist, Robert K Merton. Merton coined the term *to show that eminent scientists will get more credit than a comparatively unknown researcher, even if their work is similar. It also means that credit will usually be given to researchers who are already famous.*

Evaluating effectiveness of Research Grants

- This requires some thought
- Jaffe (2002) draws attention to the problems of ‘selectivity’ and ‘crowding out’
- Selectivity occurs since the governmental agency is, of course, trying to select the best R&D projects or the best firms to fund: hence any ex post evaluation has a biased sample of good projects and firms with no comparable group. This makes it difficult to isolate the grant scheme itself
- Crowding out refers to the idea that the grant may simply replace private R&D spending since the good project would have been funded anyhow.

Tax incentives vs Research Grants

- On the one hand, R&D tax credits are not targeted to a specific group of firms or projects, but rather to all potential R&D performers. They are therefore industry, region and firm-neutral
- Grants on the other hand can be directed to specific projects that have high social returns and are more dependent on discretionary decisions by governments.
- In general tax credits are used mostly to encourage short-term applied research, while direct subsidies are directed more to long term research.

Research Grants Vs Tax Incentives

	PROs	CONs
Tax Incentives	Higher political feasibility Less bureaucratic -> More predictable Stability of R&D incentive policy	A blunt instrument Inefficient reward of currently-finished projects
Research Grants	Discretion provided to decision makers Reward on a “case-by-case” basis Selective incentive system	Annual budget review Temporary and unstable Require bureaucratic mechanisms

Conditions under which the instruments are effective

- Mani (2002) had demonstrated through a series of country case studies that financial instruments to promote innovations are effective only when certain what may be termed as sufficient conditions are met.
- The most important of these conditions are the availability of and quality of scientists and engineers.

Empirical illustrations

- For instance, South Africa has some of the most attractive financial schemes, research grants and tax incentives to perform R&D. But the density of R&D researchers is very low in that country. Consequently, the GERD to GDP ratio has not shown any increase over the years.

- *Similar is the case of India as well*. Although having the world's most generous R&D tax incentive scheme, India's GERD to GDP ratio has not shown any increase over the last several years. This is because, as seen earlier, the density of scientists and engineers engaged in R&D is one of the lowest.

Examples of Malaysia and Singapore

(both have increased their respective densities of scientists and engineers in R&D which resulted in significant increases in R&D intensities)

Singapore	GERD to GDP (%)	Density of S&E per 10, 000 labour force		Malaysia	GERD to GDP (%)	Density of S&E per 10, 000 labour force
1990	0.81	27.7		2000	0.5	15.6
1991	0.96	31.2		2002	0.69	18
1992	1.12	37.2		2004	0.63	21.3
1993	1.02	37.6		2006	0.64	17.9
1994	1.04	38.5		2008	0.79	28.5
1995	1.1	47.7		2009	1.01	47.1
1996	1.32	50.1		2010	1.07	59.4
1997	1.42	53.4		2011	1.07	58.07
1998	1.74	57.8		2012		57.45
1999	1.82	62.6				
2000	1.82	66.1				
2001	2.02	69.9				
2002	20.7	67.5				
2003	2.03	73.8				
2004	2.1	80.9				
2005	2.16	90.1				
2006	2.13	87.4				
2007	2.34	90.4				
2008	2.62	87.6				
2009	2.16	87.8				
2010	2.01	90.2				
2011	2.16	91.3				
2012	2.02	89.6				
2013	2.03	92.8				

Policy response to improving human resource in science and engineering-1

- Increasing the density of scientists and engineers will have to be tackled from the both the supply and demand side of the spectrum.
- Increasing the enrolment, especially at the tertiary level, in science and engineering subjects, can increase the supply of S&E personnel.

Policy response to improving human resource in science and engineering-2

- In most countries this is, relatively speaking, easily done, by increasing the seats that are available for science and engineering subjects. Unfortunately, this increase is very often done at the cost of quality with the result that the students who are graduating from these institutions are hardly suited or employable.

- The demand side of the story is even more complicated as the demand for science and engineering careers are limited by their relatively less attractive incentive schemes

- For this the ideal policy response is to incentive science and engineering as a career choice.

For further reading.........