Public policy to enhance the capacity for Industrial Innovations in Developing Countries

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I. Introduction

It is generally accepted that technology is central to many changes that are taking place in both the manufacturing and service sectors of a range of countries including that of many developing ones. In most developing countries much of technology creation is still happening in government research institutes and universities, which are divorced from the production system. Consequently bridging a link between research and production has always been a problem. Increasingly the belief is that production enterprises, in both the private and public sectors must be encouraged to commit more resources to local technology generating activities. Very often these technology-generating activities takes place through formal R&D projects initiated and performed by the production enterprise itself, although it is not just restricted to R&D projects alone. Given the possibility of severe market failures in the financing of R&D, it is essential that the state have to step in by giving a variety of financial and non-financial incentives to the enterprise such that possible underinvestment in R&D is avoided or lessened. In the context, the purpose of this policy brief is two fold. First, it outlines the various financial instruments have been put in place by a host of developing countries to encourage the creation of local technology generating efforts at the enterprise-level. Second, it also discusses the conditions under which such instruments are effective in achieving the desired goals. The brief this delves on practical policy concerns of many developing countries in their attempt towards raising the level of local technology generating efforts at the level of their production enterprises.

II. Growing importance of developing countries as generators of technology

Despite its limitations as a measure of local technology generating efforts or innovations, there is now much consensus on the fact that patents are a good indicator of this activity. If one analyses the distribution of patents granted in the U.S. it is seen that the share of developing countries have been increasing. Based on this fact, one could argue that the potential for generating new technologies by developing countries have shown some dramatic increases (Table 1). But a closer analysis of this Table shows that this innovative performance of developing countries is restricted only to just 11 countries, namely Argentina, Brazil and Mexico from Latin America, South Africa from the whole of the African continent, India, China, Hong Kong, Singapore, Malaysia, Taiwan and

South Korea from Asia. Even within these better performing countries (with the possible exception of Korea and Taiwan), innovative efforts are restricted to a small sample of domestic firms. It is possible to discern three groups. At the top end, are the traditional Asian Tigers consisting of South Korea and Taiwan, followed by two Asian cubs, namely Singapore and Korea, followed by 7 developing countries (China, India, Brazil, South Africa, Argentina and Malaysia). Although still small the number of patents granted to inventors from these developing countries has increased tremendously and consequently theses developing countries are slowly emerging us potential creators of new technologies.

Majority of developing countries are not involved in any local technology generating efforts despite the fact that given the location specificity of technologies, even imported technologies will have to be adapted to local conditions. This adaptation is, very often, accomplished through investments in R&D activities. Thus the management of imported technology from abroad does entail local R&D efforts as well. In short, although, some developing countries have become potential creators of new technologies, majority of them are still mere assemblers of imported technologies. Moving up the ladder of technological development is an incremental effort. Studies have shown that even to process imported technologies effectively firms in all sorts of developing countries, potential creators of new technologies and assemblers of imported technologies, will have to invest in local R&D and other local technology generating efforts. And in order to encourage firms in doing so, governments have designed a variety of financial instruments. In the next section, we map out a range of these instruments.

Table 1: Developing countries as potential creators of new technologies,

(Based on the number of US patents granted to inventors from these countries)

	All Countries	Two Asian Tigers	Two Asian cubs	Asian NICs	China	India	South Africa	Brazil	Mexico	Argentina	Malaysia	Developing countries	Potential for creating new technologies
Up to 1990	1815531	2940	580	3520	240	329	1981	552	1385	558	38	5083	0.28
1990	90365	957	64	1021	47	23	114	41	32	17	3	277	0.31
1991	96511	1311	65	1376	50	22	105	62	29	16	12	296	0.31
1992	97444	1539	92	1631	41	24	97	40	39	20	5	266	0.27
1993	98342	1968	98	2066	53	30	93	57	45	24	13	315	0.32
1994	101676	2386	108	2494	48	27	101	60	44	32	10	322	0.32
1995	101419	2781	139	2920	62	37	123	63	40	31	7	363	0.36
1996	109645	3390	176	3566	46	35	111	63	39	30	12	336	0.31
1997	111984	3948	175	4123	62	47	101	62	45	35	17	369	0.33
1998	147518	6359	280	6639	72	85	115	74	57	43	23	469	0.32
1999	153486	7255	299	7554	90	112	110	91	76	44	30	553	0.36
2000	157494	7981	397	8378	119	131	111	98	76	54	42	631	0.40
2001	166037	8909	533	9442	195	177	120	110	81	51	39	773	0.47
2002	167333	9217	643	9860	289	249	113	96	94	54	55	950	0.57
2003	169028	9242	703	9945	297	341	112	130	84	63	50	1077	0.64

Note: 1. Two Asian countries are South Korea and Taiwan; 2. Two Asian Cubs are Singapore and Hong Kong, SAR; 3. Asian NICS are South Korea, Taiwan, Singapore and Hong Kong; 4. Developing countries are China, India, South Africa, Brazil, Mexico, Argentina, and Malaysia.

Source: United States Patent and Trade Mark Office, http://www.uspto.org/

II. Public innovation policies to promote local technology generation efforts at the firm level

The basic rationale behind public innovation policies is to combat private underinvestment in R&D. Following Leyden and Link (1992), the scope of public innovation policies can be divided into:

- the creation and maintenance of a legal environment conducive to private sector investment in innovative activities. This is created by legal measures which enhance the power to appropriate the fruits of R&D. Patents and the relaxation of antitrust activity are the primary means by which the government creates such a conducive environment; and

- the provision of sufficient stimuli to overcome the natural inclination of private agents to consider only their private benefits when choosing the level of innovative activity in which to engage. This takes a variety of forms ranging from governmental grants and contracts to targeted tax incentives.

The public innovation policies vary significantly across countries[1]. Table 2 summarises the major instruments.

Table 2: Components of Innovation Policies

Type of measure → / Relationship with the market ↓	Financial measures	Non-financial measures
Public provision of goods and services	• Subsidising exchange of R&D personnel between public and private sectors	• Policies aimed at diffusion of technology • Human resources development policy • University and government R&D • Industrial standards
Modification of market incentives	• Tax incentives for R&D • Direct funding through grants, soft loans, loan guarantees for R&D projects • Promotion of National R&D projects • Joint cooperative R&D projects between government and the private sector	• Public procurement • particularly in defence • The intellectual property right (IPR) regime • Industrial and trade policies
Support of the improvement of market mechanism	• Creation or improvement of specialised financial market mechanisms (e.g., venture capital)	

Source: Own Compilation

Of the various policies, the financial measures, and among them the tax incentives, have attracted much attention and analysis. Tax incentives possess a number of attributes that are palatable to policy makers during a phase of economic liberalisation. The main popularity of the tax incentive system arises from the fact that it interferes less with the market mechanism so it is not surprising that public innovation policies have been equated, very narrowly, with tax incentives and other financial measures. However, in current discussions and in the context of developing countries, some of the non-financial measures are equally important. Among them we focus our attention on two such measures, namely human resources and industrial standards. This is because as

[1] According to World Bank (1998) public innovation policies should consist of: (a) Governments encouraging research either directly through public R&D or indirectly through incentives for private R&D. Direct government R&D includes that financed at Universities, government research institutes, science parks, and research-oriented graduate schools. Indirect support for R&D includes preferential finance, taxes concessions, matching grants, and the promotion of national R&D projects. (b)Governments developing core strengths in basic science and technology, as that is not only necessary to maintain access to the global pool of knowledge but also to adapt that knowledge to local use.

mentioned before innovation policies will have to undergo significant changes according to the potential technological capability of a country. For instance, all developing countries can no longer be considered as a homogeneous group especially in terms of their technological capability. Some developing countries (such as the East Asian and some Latin American countries) are creators of technology while others (such as all the countries in Sub-Saharan Africa and some countries in South Asia, Latin America and the Middle East) are mere assemblers of technology imported from elsewhere. I denote the former group as Type 1 and the latter as Type 2. For the Type 1 countries, I argue that the financial measures are more important and effective while for the latter group of technology assemblers (Type 2), the non-financial measures must precede or must receive more emphasis than the financial measures.

The basic objective of all innovation policies is to increase the supply of technologies to local firms. But it is now well known that merely increasing the supply of technologies need not necessarily lead to positive or desirable outcomes for the economy as a whole. This is because increases in supply must be matched by increases in the demand for technology as well (Kim, 1997). Most developing countries are characterised by low levels of demand for technologies as a result of the high barriers to entry (both domestic and foreign) and therefore domestic firms have little or no real incentive to effect technological improvements: the Indian passenger car market is a good example of this point. The technological development of successful East Asian countries such as Korea (Kim, 1997) has shown that trade and industrial policies must back innovation policies, which increases the demand for innovations.

i. Financial Measures

The two most commonly occurring financial instruments are tax incentives and research grants.

(a) Tax Incentives

The fiscal measures to promote innovation have assumed much importance in current discussions on public innovation policies2. Among the fiscal incentives, the most important and widely used instrument is tax incentives. A survey by the OECD (1996b) has for the first time quantified exhaustively the entire gamut of public support to manufacturing R&D by the major public players in national R&D systems of the OECD countries. Data are reported according to the above-mentioned three categories. (See Figure 2 for the trends by type in public support.) R&D contracts signify the most important component they have been almost stagnant. The direct support to R&D is the next most important segment and it has been growing at a rate of nearly 9 per cent per annum: the decline in 1993 is perhaps due to reporting gaps. All three together accounts for as much as 15 per cent (approximately) of the total industrial R&D budget of the region. Since direct support to R&D is the one that is relevant for our discussion I shall now present the details on it.

[2] See OECD (1996a and 1996b).

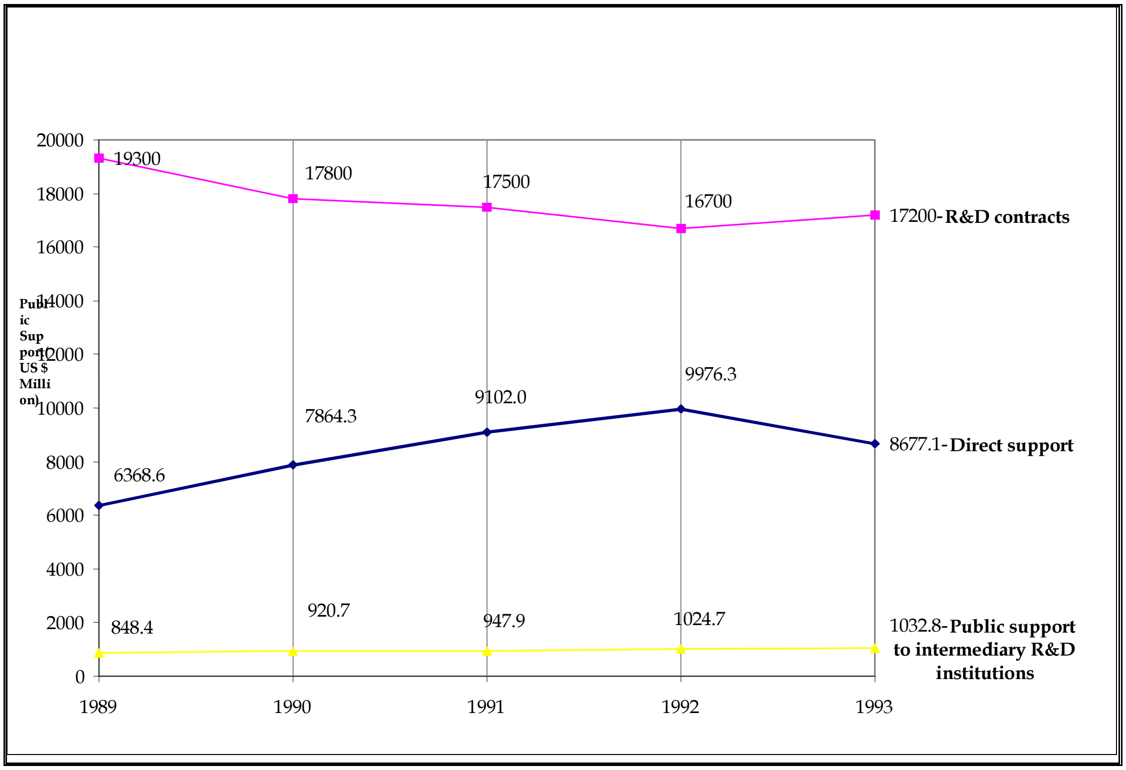

Figure 2 Public Support to Industrial R&D in Developed Countries
Source: OECD (1996b)

Within the direct support to R&D the share of tax incentives has gone down significantly while that of direct grants has actually increased. (See Table 2.) This shows that in the free market economies, direct grants for specific projects in the private sector are becoming very popular despite the fact that grants interfere with the market mechanism.

Among the direct support mechanisms, grants appear to be the most dominant form. In some countries like Israel, for instance, the entire support from government to industry is in the form of direct grants (Mani, 2002) Moreover it has also increased its share rather significantly. Tax concessions, while the second most important, have eroded their share by nearly one-half. This disenchantment with tax concessions warrants a closer look. This is because developing countries such as India are showing signs of replacing direct support to R&D with indirect subsidies such as tax concessions. I am interested in two dimensions of this subsidy:

Table 2: Direct Support to R&D in Developed Countries
(Percentage Share)

Financing Instrument	**1989**	**1990**	**1991**	**1992**	**1993**
Research Grants	42.5	45.6	45.6	53.5	58.5
Tax Concessions	35.4	31.4	31.10	19.80	19.80
Loan Guarantees	1.2	1.3	1.70	4.6	0.9
Mixed	20.4	21.0	20.5	20.8	19.1

Unclassified	0.50	0.70	1.36	1.40	1.70

Source: OECD (1996a)

- the specific form it has taken in various countries (Table 3); and
- examining the empirical evidence on its efficacy as a tool for stimulating investments in R&D by private sector firms.

Table 3: The Nature of Tax Subsidy for R&D across Countries

Nature of the deduction	Availability of tax deduction for revenue based R&D (%)	Availability of tax deduction for capital expenditure on fixed assets linked to R&D(%)
Total expenditure	85	90
Part of the expenditure	5	0
An amount greater than the expenditure	10	10
If deduction is available, is that deduction available:		
• In the first year	55	10
• In the period 1-3 yrs	0	30
• In the period >5 yrs	20	40
• At the tax payer's discretion	45	0

Source: KPMG (1994)

Nature of Tax Subsidies across countries

This is based on a survey of tax treatment of R&D expenditure across 20 developed and developing countries[3.] The following stylised facts emerge:

- the majority of the countries covered in the sample allow almost the entire revenue and capital expenditure expended on R&D to be deducted from the taxable income during a year;

- in fact in some 10 per cent of the number of countries4 an amount even greater than what is spent is allowed to be deducted; and

- much of the revenue expenditure deductions is admissible in the first year itself while much of the capital expenditure deductions is admissible in the first five years.

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[3] These countries include 13 developed countries (Australia, Belgium, Canada, France, Germany, Ireland, Italy, Japan, the Netherlands, Spain and Switzerland, the UK and the US) and 7 developing countries (Brazil, China, Hong Kong, Korea, Singapore, South Africa, and Taiwan).

[4] The countries are Australia, Singapore and Belgium.

Effectiveness of R&D Tax Subsidies

There are two key aspects to evaluating the effectiveness of the R&D tax subsidies. One relates to the efficacy of tax subsidies in general as a policy tool for spurring increased research spending. The other aspect concerns how effective the Research and Experimentation Tax Credit in particular has been in stimulating increased R&D spending, and at what cost in foregone federal tax revenues. These issues are analysed in turn.

Direct government funding is apt to be more efficient than tax incentives when the policy aim is to enlarge the stock of basic knowledge available to domestic firms: direct funding is likely to raise total spending on basic research by more than the amount spent by the government, whereas one unit of tax incentives is likely to yield significantly less than one unit of additional spending on basic research because of its relatively large spillover effects. But if the policy aim is to boost a country's rate of commercialisation of new products, processes or services, then a tax incentive has some advantages over direct funding. Success in commercialisation hinges on a sound understanding of the market, and tax incentives have the advantage of leaving the decisions of which projects to fund in the hands of private firms rather than government agencies. Even with the tax subsidies, firms will still be putting up most of the money for projects they pursue, which ensures that they, not the taxpayers, will bear most of the risks of failure. By contrast, direct funding of commercial R&D could foster a misallocation of resources among major sectors of the economy.

In addition, tax incentives involve less interference in the market and thus allow private sector decisionmakers to retain autonomy in devising their R&D strategies in response to market signals. Further, it is held that tax incentives are easier to administer and are less discretionary compared to direct project subsidies often granted on a case-by-case basis. Project grants are also less predictable as they are subject to yearly budget allocations.

But tax incentives also have a number of limitations, of which the most important are:

- the R&D tax subsidies tend to operate as entitlement: all firms that qualify may claim a subsidy. In addition, a credit is easy to abuse by classifying routine research expenses as innovative;

- tax incentives are blunt instruments: a tax incentive such as a credit cannot be targeted at R&D projects with large spillover effects, unlike direct funding programmes; and

- the propensity to relabel routine expenditures such as quality control and testing as R&D expenditure and then claim tax incentives is also very high, especially in the developing-country context.

Empirical Evidence on the Efficacy of Tax Incentives

There are two methodologies for empirically testing this proposition. Most or all of the studies are based on the Research and Experimentation Tax Credit of the United States. The first technique employs the simple survey method of essentially questioning senior R&D managers about their response to changes in the tax incentive. The second technique employs econometric techniques to estimate the price elasticity of R&D- the percentage increase in R&D induced by a percentage fall in its cost.

The various studies provide mixed evidence for claims about the amount of R&D investment induced by the credit per dollar of forgone revenue. No clear-cut conclusions can be drawn.

(b) **Research grants**: Increasingly research grants are becoming the predominant way of funding local technology generating efforts. This is despite the fact that research grants are inherently discretionary implying that gets how much is decided by someone in the government. However research grants are more appealing as an innovation policy instrument. When the policy aim is to enlarge the stock of basic knowledge available to domestic firms, research grants are preferable. Research grants are often compared with tax incentives. Table 4 summarises the main points of this comparison. Outcomes or effectiveness of grants are more easily measurable as grants are very often tied to specific projects. At the end of the day, if the project results in tangible outputs, then the grant mechanism is considered to be a success.

Table 4: Financial instruments to promote innovation: Research Grants Vs Tax Incentives

	Prospects	**Consequences**
Research grants	• Descretion provided to decision makers • Reward on a 'case-by-case" basis • Selective incentive systems	• Annual budget review • Temporary and unstable • Inefficient reward of currently finisherd projects
Tax incentives	• Annual budget review • Temporary and unstable	

	• Require bureaucratic mechanisms	

Source: Own compilation

Although research grants may appear to be much more appealing, there are many practical policy questions that need to address in its implementation. This is especially so in developing countries. Administration of research grants implies a major trade off between accountability and efficiency which the grant administrators (politicians and bureaucrats) require and between autonomy and effectiveness, which the grant-recipients (firms, scientists in research laboratories) desire. Because of the increased competition for limited funds trade-offs have to be made between fairness and efficiency. The power in the grant distribution process initially resides in gatekeepers who reside in the funding agencies administering the granting process and in the peer review cadre.

Three models could be recognised in attempts to explain the resource distribution process: an accumulative advantage model, a merit model, and a 'political' model in which elite scientists exert hegemony over grant distribution. Accumulative advantage – existence of bias in the distribution of research grants

IV. Conditions under which financial incentives are effective for local technology creation

Financial incentives such as tax incentives and research grants are effective only when the country in question has sufficient number of scientists and engineers A more formal way of stating this is that there exists a positive correlation between the density of scientists and engineers and the degree of research intensity of countries. Empirical substantiation of this proposition could be found even within a sample of countries variously referred to earlier as potential creators of new technologies or Type 1 countries (Mani, 2002). Even countries such as Brazil, India and South Africa, which are supposed to be having a large total pool of scientists and engineers, have a low density of scientists and engineers actually engaged in formal R&D projects. Analyses of this low density figures showed that it was due to both demand and supply factors. This could be elaborated as follows. First of all, as mentioned earlier, the low density may just be a manifestation of the low demand for innovations that exists due to the concentrated nature of internal markets coupled with lack of external competition. If this is indeed the case, then encouraging local technology generating efforts through provision of financial incentives is likely to bear fruits only if domestic and external competition to the local enterprises is increased. This requires industrial and trade policy instruments. Second, the low density may be a reflection of supply side factors. For instance, it may be due to low enrolment ratios: low enrolment at the tertiary levels in science, engineering and, mathematics. Further the incentive systems for research, as a career is not that attractive in most countries. Consequent to this even if the country has a large pool of scientists and engineers, given the low incentive systems in place, firms are unable to attract a sufficient number of well trained scientists and engineers to their research laboratories leading to low density of scientists and engineers engaged in R&D. A third factor that can possibly affect the low density is the mismatch between what is required by the industry and what is supplied by the higher education system. Fortunately public instruments can be designed to impact upon all the three factors.

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