Economics of R&D

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Abstract— ***Markets are efficient resource allocators for private goods but not so in the case of public goods which have social returns larger than private returns. Research activities have positive externalities and spill over effect which market fails to take into account. This leads to market failure and thus under-investment in research activities. To correct this market failure government intervention is expected to re-establish the balance of cost and benefit equation for research at a socially optimal point where social costs and benefits reach equilibrium.***

Keywords— Public goods, private rate of return, social rate of return, resource allocation, equilibrium, market failure, R&D.

I. INTRODUCTION

Science and technology are important determinants of economic growth. In the present age of science, all new innovations are adding new dimensions in every field of life. R&D activities add something to the present domain of knowledge, which benefits each and every person in one way or other. Thus, research and innovations are to some extent a public good, i.e., these are 'non-rivalrous' and 'non-excludable'. A good is non-rivalrous when consumption of that good by one person does not reduce the amount of the good left to be consumed by another person, like movies, it does not get exhausted after consumption. Non-excludability implies those who does not pay cannot be excluded which invites free-riders, like defence expenditure by government. This nature of public goods makes them difficult to be priced.

R&D exhibits similarity of nature with public goods. A better technology invented by a firm by heavily investing in its R&D activities can be imitated by other firms as well to reap its benefits thus a possibility of free riders cannot be eliminated. Thus the full economic value of a scientific advance is unlikely to accrue to its discoverer, especially if the new knowledge o=can be replicated or disseminated at low cost. Unlike private goods, market does not allocate resources efficiently in case of public goods. Where applied research still have some end uses so it can be priced, basic research has nothing to sell, as it is difficult to appropriate the benefits of basic research.

In this paper, an attempt has been made to describe why market tends to under-invest in research, costs associated with research, benefits which are supposed to be received and probable measures which can rebalance this cost benefit equation to encourage research activity in the economy.

II. CURRENT STATE OF MARKET UNDER-INVESTMENT IN R&D

Market under-invest in some sector if private cost benefit equilibrium is established at a low level than socially acceptable equilibrium point. The positive externalities accruing from research activities make them less beneficial for private agents. When firms determine, based on their expectations from the outcomes of research, that their private rate of return is less than the minimum acceptable rate of return, they do not invest adequately in research, this causes under-investment. The reason firms perceive the rate of return less than acceptable is "market risk". There is a risk that the actual outcome of the research activity would be different from the expected outcome. Technical uncertainties also come in way, as it is uncertain if the outcome would tackle the technical problem faced by the firm efficiently, if it would be useable and if the firm would be able to maintain excludability. It may be difficult to assign intellectual property rights to the technology and might be quickly imitated by other competitors so that the firm may not receive adequate returns on its investment. These factors are the reasons firms don't invest

adequately in R&D, this is a situation of market failure. In the situation of market failure government is expected to interfere and ensure proper and efficient resource allocation.

Society, to some extent, has evolved with a reward system that encourages the production and sharing of knowledge and scientists are motivated to do research by a desire to establish priority of discovery. But these researches still suffer on economic front. It is difficult for them to raise funds as private investors want return on their investments which is uncertain in research because unlike conventional sectors, production of final goods (successful invention) cannot be guaranteed here by following predefined process. Thus, basic research has been traditionally supported either by government or philanthropists, which is evident from the given data of funding for higher education research for various countries.

As evident from the table below, almost all the funding for university research has come from the government in most of the countries, except Japan. Other sources of funds for research accounted for a very small part, be it business or non-profit organisations.

TABLE I
FUNDING FOR RESEARCH IN HIGHER EDUCATION

		Belgium	Denmark	France	Germany	Ireland	Italy	Japan	Netherlands	UK
Gov-DGF	1981	39.5	10.9	45	98(DGF+ GUF)	14.9	96(DGF+ GUF)	16	5.7	15
	1995	38.0	22.9	46	20	20.0	93(DGF+ GUF)	10	6.3	30
	2006			36	23		18	12		35
Gov-GUF	1981	43.4	85.6	53		67.6		42	91.1	65
	1995	34.9	66.8	45	70	42.0		42	79.3	38
	2006			53	58		76	39		34
Business	1981	8.7	1.0	1	2	7.1	3	1	.3	3
	1995	10.6	1.8	3	8	6.9	5	2	4.0	6
	2006			2	14		1	3		5
NPO	1981	0	1.6	.1		2.6		0	2.3	5
	1995	1.0	4.5	.5		2.5		0	6.5	14
	2006			.6			1	1		14
HE	1981	2.9	0	1		.4	0	41	.3	9
	1995	6.8	0	4		4.5		41	.3	4
	2006			7				45		4
Abroad	1981	1.8	1.3	0		7.3	1	0	.3	2
	1995	8.7	4.2	2	1	24.0	2	0	3.5	8
	2006			3	4		4	0		8

Source- Aldo Geuna, Journal of Economic Issues, September 2001; Aldo Geuna class slides and The Changing Rationale For European Research Findings
Gov-Government, DGF-Direct Government Fund, GUF-General University Funds, NPO-Non-Profit Organisations, HE-Higher Education's own fund

III. COSTS ASSOCIATED WITH R&D

Every good produced has some cost of production. As in conventional sectors, research also produces output by employing inputs. These inputs include equipments, knowledge, time and human capital. These inputs are not free of cost. Even an almost equipment-less research, like survey, also costs so much in terms of travelling expenses etc. Time consumed in research also have opportunity cost, as that time could have been utilised in other productive activities.

For example, a medical research, be it applied or basic, would need equipments, technicians to run the equipments, these equipments will have depreciation cost, patents and permission costs and costs on animal trials, even cost of keeping animals for the research period. One researcher was paying Stanford $800,000 for keeping mice.[2]

Similarly research in other disciplines also has a variety of costs. From point of view of private investors, cost of research also includes the cost incurred in adopting the findings of the research in practical situations, i.e. the cost of applying the research in practice. This cost includes changing/updating equipments, methods, factor proportions and upgradation of skills of manpower employed.

These costs affect the demand side of R&D. Higher the costs, lower will be probability to recover these costs with constant returns. Moreover, research being an unconventional sector, production of output is not certain even after employing inputs. This uncertainty reduces the probability of recovering these costs. This leads to higher actual costs compared to nominal monetary costs as some successful inventions have to recover the costs of unsuccessful inventions too to keep the firm, as a whole, in profitable situation.

IV. RETURNS ON R&D

Any resource employed anywhere need some returns on their employment to keep them in the employment. The opportunity cost of a resource has to be met to keep it employed. Real returns include other benefits as well in addition to nominal monetary return. Researchers get two types of rewards in return of the hard work they employ-

A. Psychological rewards

B. Monetary rewards

Psychological rewards are can further be classified into two types, the pleasure of finding things out &the appreciation and recognition they get by peers and society at large. As Richard Feynman said, scientists are motivated by an interest in puzzle solving. It is this interest which attracts them in science. Solving the puzzle, then, becomes a reward in itself. Recognition and appreciation for their work also forms a part of psychological rewards, as it gives satisfaction to see their work getting valued. But measuring these rewards involves value judgement which makes it subjective. However, the economic resources applied in research need economic rewards in order to remain sustainable. These monetary rewards include investment from the market (based on the value market see in applying the research in practice), prizes and award money researchers get, funding received from government and not-for-profit foundations and royalties.

In addition to these personal rewards, the firm which takes into the R&D activities receives return in terms of the benefits it may reap from the invention of new technology. The new and improved technology reduces the cost of production of a firm thus giving it an edge in the competition.

V. TO REACH THE SOCIALLY OPTIMAL POINT OF EQUILIBRIUM

Where the returns accruing from the R&D investments equals the costs associated with it, equilibrium expenditure is decided. Although marginal cost of research does not remain constant but for theoretical ease we can take it as a constant cost. The point of equilibrium for R&D expenditure from private perspective in the following diagram is F, while socially ideal optimal point of equilibrium is point E.

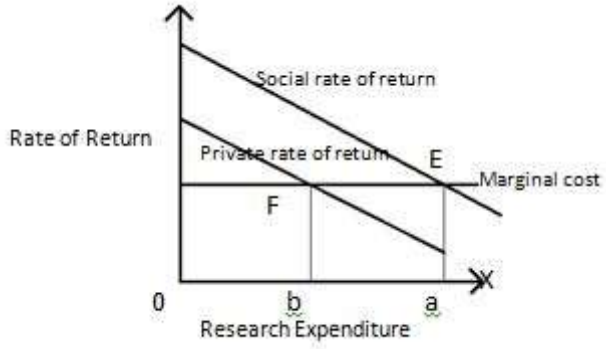

Figure 1. Equilibrium of costs and benefits

Here, ideally the equilibrium should have been established at point ‘E’ where marginal cost equals marginal overall returns (social as well as private). But as private benefits are less than total benefits in the presence of social externalities the balance is skewed at point ‘F’. Thus, where ‘Oa’ amount of expenditure should have incurred on

R&D activities, only 'Ob' amount is been spent. To increase the expenditure till the equilibrium level, either the cost line has to be brought down or rate of return has to be increased.

Thus, to improve the cost benefit equation, two types of measures are there. First, which reduces the cost and second, which increases the benefits.

If the cost of research is reduced, the marginal cost line would shift towards the X axis, while both lines of returns remaining the same. This shift in marginal cost line shifts the point of equilibrium for private firms towards the right side which increases the optimal expenditure on R&D activities.

Similarly balance can be established at the optimal point through increasing private rate of return, which will shift the private rate of return line upwards and thus shifting the equilibrium point to the right.

These measures can include the following-

A. Tax incentives-

A provision of tax credit on the expenditure made on R&D activities by a firm can significantly lower the cost of research. Tax incentives have the psychological advantage of achieving a favourable industry reaction without much interference in the marketplace. Private sector recipients still enjoy the autonomy regarding the use of the incentives.

As adopted in the USA, the Internal Revenue Code which codifies and expands tax laws pertaining to the R&D expenditure of firms, have a provision for permitted businesses to deduct fully R&D expenditures in the year incurred. Over the years the tax credit had been modified in terms of the definition of the R&E base, like the inclusion of expenses related to administration of R&D or research conducted outside the national boundaries.

There is not sufficient information available to conduct a complete benefit cost analysis of the effectiveness of the R&D tax credits on the economy but it cannot be denied that these credits encourages private players to invest more in research by lowering the cost associated with it. Although these incentives costs scarce government resources, but the social benefits associated with research outweighs the costs.

B. A robust patent system-

While tax incentives encourage research by reducing the cost associated with it, patents try to increase the private rate of return. It attempts to correct the market failure by including the principal of excludability in research findings. Once research outcomes are made excludable, the firm investing in the R&D assured of enjoying the return over its investment.

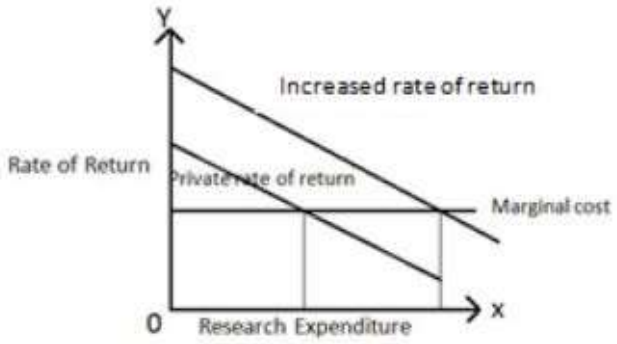

Figure 2. Effect of patents on the private rate of return

In the absence of patent system, the optimal point of R&D expenditure would have been Y, where private marginal cost equals expected private marginal return. But this level of investment is insufficient from the social point of view. This is a state of market failure. To correct the market failure patents are introduced which increases the private rate of return by 'ab' amount, thus rebalancing marginal cost and marginal return at X amount of R&D expenditure which is optimal point for firms as well as society. Empirical

findings suggest a similar pattern. Studies by Hall et al(1986), Pakes and Griliches(1984), Acs and Audretsch(1989) and many more established a strong positive correlation between R&D expenditure and patents.[3]

C. Research collaborations-

Research collaboration means formal or informal partnerships among firms, government or university partners in the conduct of research. It may help to overcome element of market failure by reducing technical risk to the R&D conducting agent. Partners may aim to develop or refine a new product, improve production processes, set standards, or develop technology to meet environmental regulations. It would be cost saving to each partner, reduce time to reach market and ensure better appropriability of R&D results. As seen in table 1, industry forms a very small part of funding for higher education research, this remains an untapped source. Areas which are of importance for market, like applied research should ensure more collaboration between industry and research agents so as to tap this under-utilised source of funds.

D. Other measures-

Other measures may include psychological factors that affect the research. The rules and regulations relating to permissions and patents should be made researcher friendly. For instance, in medical areas it consumes a large amount of energy and resources to take permit for human trials and sometimes animal trials too. Uncertainty of having intellectual property rights lowers the expected returns for the researcher and the firm also. Psychological factors must also not be avoided. Rewards and recognition play a vital role in motivating researchers. There must be a transparent mechanism for rewards.

VI. CONCLUSION

The rate of growth of an economy is positively related to technological advancement which in turn depends upon the research and development activity taking place in and around the economy. To increase the R&D activities, there is a need to make this sector economically attractive and viable. Efforts must be made to lower the costs involved in this sector and increase potential benefits. The sources of funds should be consistent enough to rely on them and large enough to keep the ball rolling.

As research has properties of public goods, it involves market failure. In such a state, government is expected to interfere to correct the market failure. Government can play a role in reducing costs and increasing benefits and thus encouraging research through tax incentives, researcher friendly system, robust patent strategy and rewards and recognition to researchers. Government incentives can promote indigenous innovations. As factors, resources, environment, attitude, methods, socio-politico-cultural surroundings, skills, development level and capacity to adapt differ from country to country, an indigenous research will be more peculiar to country specific situations and problems and this be more helpful in improving living standard of the people and growth rate of the economy.

ACKNOWLEDGEMENT

I thank my teachers from Jai Narain Vyas University, who provided insights and expertise that greatly assisted the study and helped in improving the manuscript. All remaining shortcomings are my own.

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