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Theory of Research Policy
and their Application to
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SOME REMARKS ON THE THEORY OF RESEARCH POLICY AND THEIR APPLICATION
TO UNIVERSITY RESEARCH

by

Beat Blankart*

In most capitalist countries research policy seems to represent a somewhat ambiguous compromise between at least three divergent viewpoints: a free market economy should ensure the optimal use of a given stock of knowledge, monopoly protection through patent system should encourage a sufficient production of inventions, and finally government spending is regarded to represent a third way. A consistent theory of research policy would be able to bring these aspects into a closed framework. Unfortunately, economic theory is far away from such a point. This paper attempts to move some few steps of a long way toward that goal.

In section I, some recent developments in the theory of inventions developed by Hirshleifer (1971, 1973) will be discussed and integrated in the traditional theories of Machlup (1958, 1962, 1968), Arrow (1962), and others. In section II, I shall apply these concepts to research in a free enterprise university system which is supposed to be governed by private demand alone. In section III, government spending will be introduced and its political

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consequences will be discussed. Section IV will show the incentive effects of a system of honorary decorations for research. Section V will conclude the arguments.

Most proposals and arguments discussed in this paper are judged from the point of view of optimal compensation of researchers. By "optimal" I mean that private marginal benefits of an additional invention should be equal to social marginal benefits in order to induce inventors to produce until these two magnitudes equalize marginal cost (given the usual properties of benefit and cost functions).

I Alternative Theories of Inventive Activity

The traditional individualistic theory of invention production worked out most carefully by Arrow (1962) deals with two major fields: risk on the one hand, and indivisibilities and appropriability problems on the other.

First the production of inventions is risky because it is by definition impossible to predict the result. If there were insurance contracts against inventive failure, the risk function could be separated from the inventive function and optimality could be attained. But such insurance contracts would diminish inventors' incentives to be efficient because of "moral hazard". This would increase insurance premiums so much that demand is likely to fall to zero. Therefore the free enterprise system is not expected to provide the desirable amount of insurance contracts which would lead to an underoptimal production of knowledge. However Demsetz (1969) shows that Arrow's argument is not so straightforward as it seems to be. Risk reduction involves cost

such as e.g. "moral hazard" and if insurance contracts are not supplied it is simply because these costs are too high. Uncovered risk is comparable to iron ore left unearthed. It could not be argued that this is suboptimal.¹

Our main attention therefore does not concentrate on risk, but rather on the second question the appropriability of returns of research. This problem arises according to Arrow from the public good properties of inventions with regard to numerous potential users. Inventions are private goods as long as they are kept secret. When an owner wants to sell his invention, he has to reveal it to the buyer to allow him to evaluate costs and benefits of a possible purchase. But by this action the purchaser has acquired it without cost. No patent system could protect the supplier against the use of this information to develop alternative or further knowledge (Arrow 1962).

But even disregarding that point, a given royalty payment enforced by patent protection would not allow the owner to collect the consumers' surplus. Moreover he has an income foregone by not being able to sell his invention to extramarginal individuals. These factors diminish the return and therefore the incentives to future work for the inventor. On the other hand every monopolized sale of an existing invention for a given price for its use would lead to a welfare loss since marginal cost created by an additional user are zero.

¹Pauly (1968) shows that the change of an individual's behavior after being insured is one item in his ex ante evaluation of the insurance contract. Taking this into account, even in a optimal situation, risk averse individuals may prefer not to be insured.

In Arrows view, therefore, it is likely that not only the problem of uncovered risk but also incomplete appropriability of the benefits created by the inventor would lead to an underinvestment in inventive activities.

Hirshleifer (1971, 1973) concentrates his attention on the fact that the inventor is the owner of two commodities: the invention itself, and a "private, sure, and prior" information on the economic consequences of his invention ("foreknowledge"). He can therefore engage in large speculations on the latter before revealing his invention. Hirshleifer believes that the internalizable benefit from speculation could, under certain conditions, be much higher than the social value of the invention. In this case one would expect an overinvestment in inventive activities.

These contradictory results would lead to completely opposite governmental research policies. Since this paper aims to improve the conceptions of research policy, it seems useful to analyse the two outcomes. Let me explain the problem using a rigorously simplified model of a stationary corn economy in competitive equilibrium. Suppose further that there exists an entirely anonymous and unlimited credit market. Only two periods are regarded here: the period before and after the supply of the invention.

1. In the first case under consideration, we assume that one single individual has acquired exogenously (say by extraordinary intelligence) the private, sure and prior knowledge of a higher technology for producing corn which would be useful for all producers to some degree, but which would leave - for simplicity - the marginal product of labor unchanged. Following the theories of either Arrow or Hirshleifer, the individual has two possibilities to make profit out of his knowledge:

a. He may sell the use of his invention under the protection of a patent. Let us assume for a moment that he can charge royalties in a completely discriminatory pattern on all (primary and secondary) beneficiaries. So he would receive an amount of money what is usually called the social benefit of the invention (s. Hirshleifer 1971)¹.

b. On the other hand the inventor can use his private, sure, and prior information to engage in speculation. The following transactions will maximize his profits; he will anonymously buy all the shares on ownership of the corn economy at the given price. Then he will reveal his invention, in other words, he will supply it as a public good. In a perfectly competitive economy, innovation would take place immediately and stock prices would rise by the amount of the increase of the present value. The inventor could then resell the shares and reap the speculative profit.

In both cases (a and b), the owner of the information would receive exactly the same amount of money, viz. the full social benefit of his invention. Up to here there is no difference between Arrow's and Hirshleifer's theory.²

The point becomes more obvious if we allow that the inventor may as well speculate as obtain a patent protection. However the combined opportunities would not allow him to make more profits. The more he enforces his patent

¹Arrow (1962) does not mention the expression explicitly, but he says that, in the real world, "the product [of invention] can be appropriated only to a limited extent." (p.156). One can infer that the "product" is likely to represent the above mentioned "social benefit".

²See also H.G. Manne (1966, p. 60 - 62 and 119 - 121) for a somewhat similar argumentation.

rights, the less the stock prices would rise. The overall sum of gained profits remains constant. This contradicts Hirshleifer's arguments that pecuniary speculative benefits could be made by the inventor "quite apart from the technological benefit that the patent system attempts to reserve him" (1971, p. 572). However, I shall show in a second model that an overcompensation of the inventor is not impossible; but this outcome does not hinge on the point that patent profits and speculation profits could be realized together as Hirshleifer assumes.

2. Hirshleifer pays much attention to the problem of competitive speculation. Neglecting the social value of the invention, competitive speculation on inventions is, if it happens, a zero sum game without social return (s. also Fama and Laffer 1971); but private benefits might be very high. Hirshleifer believes that especially these distributive benefits would lead to a dynamic speculation process and so possibly to an overcompensation of inventors.

Let us construct an example where this type of overcompensation might occur. Assume two inventors A and B. Each is fully convinced of the superiority of his hitherto unrevealed invention A_1 and B_1 .¹ But A_1 fits only into the technology of the corn producing corporation A_2 whereas B_1 does only for corporation B_2 . If A_1 is superior it will be adopted by corporation A_2 , and B_2 has to shut down his business, and vice versa if B_1 is superior. By means of our unlimited credit system, A and B will engage in speculation. A will buy all the shares of A_1 and he will sell short the shares of B_1 . B will do the opposite

¹ B_1 may also describe the belief in the superiority of the status quo technology.

Suppose, after having revealed the inventions, the market will value A_1 higher than B_1 . Therefore B_2 has to shut down. As a consequence the share price of A_2 will rise and so compensate A by the social value of his invention. But in addition he will receive the benefits of his speculation on B_1 (i.e. all the benefits from the mistaken belief of B) which is purely distributive. It could be said that it is not a compensation for borne risk because each acted under full certainty in his belief. All together A receives more than the social value produced. Of course a lot of less drastic examples might be imagined. Yet the possibility remains that an inventor can reap overoptimal speculative profits due to his superior knowledge. Overcompensation, on the other hand, would lead to overinvestment in inventive activities.

But it may be useful to compare the two cases of one single speculating and two competitively speculating inventors. The single inventor has not to know about the quality of his invention. It is enough to buy and to resell the shares which is assumed to be possible without transactions costs. The competing inventors however have to compare the relative economic values of their projects. This may cause difficulties since the competing invention will ex definitione be kept secret during the period of speculation. Therefore each inventor will spend large resources to gather information on the market value of both inventions. (The amount spent is likely to be far beyond the optimum as Hirshleifer (1971, 1973) has shown.¹ For the true relative values of the inventions will come at light anyway.)

¹For another explanation of the overproduction hypothesis of informations see Fama and Laffer (1971).

But it is not at all sure that all inventors will reach fully contradictory certainty in their own beliefs. Therefore it is more likely that individuals would prefer to spread risks and to insure instead of engaging in concentrate speculations. But by doing this, the possibility to be on the winning and on the losing side increases and therefore the probability of overcompensation declines.

To sum up: The above analysis shows the conditions under which optimal compensation of inventive activities can take place. There are even few possibilities of overcompensation; but the conditions under which it would happen are much more restrictive.

II Research in a Free Enterprise University System

Let us investigate how the above outlined approaches of invention production can be applied to research in universities. First we shall assume that there is a free enterprise university system similar to that proposed by Friedman (1962); but here we assume that there is no government spending at all. We shall first abstract from teaching and look at research alone. The university, in this case, is merely a locality where research takes place. Later in this section we shall look at the combined supply of research and teaching. Furthermore we shall disregard the fact that a scientist may use capital and other facilities which he does not pay for directly.

Since, in a free enterprise university system, research activities are governed by market forces we would expect - following Arrow's hypothesis - that the system is not apt to allow internalization of produced benefits of an inventor, and a less than optimal amount of research is supposed to be carried out.-Patent protection is enforceable on principle only for very few results of applied research such as, for example, computer programs for calculations and

models.¹ For most basic inventions enforcement costs of patent protection would be very high. It is impossible to count all the readers of a specific book and to make them pay a royalty fee when they use it for any thought. A part however of the social value of a research result can be internalized: Mostly the supplied invention is bound in a book. Since the latter is a private good yielding personal advantage over reading in a public library, the consumer may purchase it and pay also for the information (s. Olson 1965; but for qualifications s. Barzel 1971).

Internalization of benefits through speculation on expected value changes on the stock market are practically unfeasible. Even in natural sciences where inventions have a more direct influence on products sold in the market, speculation based on superior knowledge would not help very much at least because most firms do not sell only one, but rather a great number of products which all together may influence the share price movements.

This is even more true for basic research results. Otto Hahn, for example, did not realize the full military consequences of his discovery on which the atomic bomb was developed (s. Tullock 1966). Finally the social scientist who has produced a device for improved management of bureaucracy or government should - under the speculation hypothesis - buy (or borrow the shares of the whole economy to have a minimal chance to internalize the social value of his invention. Moreover, since neither bureaucracy nor even a vote maximizing government do follow the rules of perfect competition, there is

¹However the property is not yet acknowledged legally as patentable.

no certainty that the idea produced by the social scientist - however useful - will also be followed by an innovation in the government sector. Therefore the value of the shares may not increase at all.

Suppose however, a single scientist having produced a new idea. He then can speculate on the human capital of his own person. When he has revealed the idea, he will remain for a limited time a monopolist for the application and further development of his invention. This gives him a temporary advantage in the university job market. But his monopoly is not perfect. In a free enterprise university system imitators will soon be on the place and supply the same product at a lower price or wage rate. Therefore the original producer is not able to internalize the full social value of his invention.¹

The opportunities to reap distributive profits out of mistaken beliefs of other scientists are practically zero, because there is no market for different risk claims - as described by Arrow (1962) - on which an individual having private, sure, and prior information could speculate against the competitor's mistaken beliefs.

Up to here we have assumed that the number of users of inventions is very large. Therefore the market worked anonymously. This condition however is not necessary. As soon as the number of users diminishes, prospects for direct negotiations between producers and users increase. The interested consumers may pay the scientist an additional sum of money to convince him to produce an additional bit of research (cf. Coase 1960, Olson 1965, Demsetz 1969).

¹Temporary monopolization of inventions is limited too if the same invention is made at the same time by different scientists (cf. e.g. the theorem of the Golden Rule of Capital Accumulation by Phelps, v. Weizsaecker, and Joan Robinson)

The possibilities to internalize returns of research may be further changed if we look at teaching by scientists. The traditional publicly owned universities are characterized by a combined supply of research and teaching. This may be regarded as a kind of tie-in sale; students are compelled to consume a bit of research too if they want to be taught at universities. Under certain conditions, this system could be applied also in privately owned free enterprise universities and so allow internalization of research returns without creating too much negative side effects. Of course, under a system of tied supply of teaching and research, demand for education would be smaller than if teaching could be bought alone. But if the price elasticity of demand is only of small value, this effect might not be substantial. Moreover if research and teaching are technically complementary activities, or if research is a technical precondition for effective teaching, a university might find it profitable to allow scientists to perform some research. If however research and teaching are substitutive activities, a tied production of research and teaching is possibly no more profitable for a competitive free enterprise university system. The law of increasing returns of specialization might make it preferable to perform either research or teaching, and so the former public good problem of research production would again arise. This could be avoided only if scientists/teachers would monopolize their supply, in other words if they would compel themselves to bargain collectively for joint research/teaching contracts. Then, the ordinary rules of monopolistic tie-in sale could be applied (s. Burstein 1960).

Thereof it can be summarized that a free enterprise university system would not lead to a zero production of research as the model of perfect competition would suggest. There are several possibilities to internalize a fraction of the inventive benefits: some patent protection, the combination of research with a private good (such as a book), speculation on the job market, direct bargaining, and, in some cases, tying of research to teaching may reward inventors even in universities of that type. However, a great deal of basic research may still remain (partially) uncompensated. We expect therefore that those inventions would be produced to a less than optimal amount. On the other hand, it becomes privately more profitable to spend personal resources in imitations of big ideas and so to reap the quasi monopoly rents of the original inventors. Such activities are the numerous applications, purifications, extensions, and tests of original ideas which Alice Vandermeulen calls "Hunting Trophies" (1972, p. 107). Of course these efforts yield some net return too, but they are expected often to be of smaller social value than original inventions.

III Government Financed Research in Universities

The society, therefore, may prefer a greater amount of research production than the free enterprise university system would provide. Suppose first that the citizens are equally well informed and that they have attained unanimous consent to spend a certain amount of money for different fields of research. This way of decision making satisfies the Pareto criterion (Buchanan 1968). However the money has to be utilized efficiently or else unanimous support will be withdrawn. The question is therefore; which way of spending is preferable if the given sum of money has to be distributed among a certain number of scientists to attain

maximum output? We disregard again the problem of the use of capital equipment and of other facilities which the scientist does not pay for directly.

The answer can be framed within two polar settings. First the scientist can be hired at tenure agreements. Under pure tenure salaries are independent of individual's research performance. A rational man would therefore diminish his research efforts after having got his appointment. However the research output is not likely to decrease to zero under tenure. Some scientists derive direct utility from carrying out research. But it is unlikely that this system would yield the highest possible research production (s. Tullock 1966).

An advising economist would prefer to choose the opposite alternative, in other words, a fully output oriented payment system. Therefore the given government provided sum of money should be reallocated according to individual's output behavior. However there arise at least two problems:

1. As above explained, government compensation would be preferable for results the revenue of which can't be internalized (especially basic research results). But just because of non-excludability, output is not measurable (Olson 1973) and therefore it is difficult to adjust salaries to this variable. Yet some progress on this field has been realized as e.g. the studies of Hansen and Weisbrod (1972) and Lovell (1973) show. Therefore, measurement of scientific output is possible on principle, but it is probably too inexact to rely on these approaches alone.

2. But even disregarding that point, possible shifts toward a more differentiating salary structure seem to be rather limited within the given sum of money. The above treated tenure payments represent also a kind of insurance. By lowering the minimum wage (in order to increase incentives

for additional research) risk averse individuals may refuse to go into the business of research production at all. Of course it may be argued the number of researchers could be reduced in order to increase the per head compensations for highly qualified research. However it is uncertain whether the expected additional output of the high level scientists will make up the loss created by the release of middle and low ranked scientists.

Given these uncertainties and constraints the present salary system in the United States is possibly not so far from what could be called a reasonably efficient payment scheme. For the case of economics this conclusion is supported by some empirical evidence in the recent study by Siegfried and White (1973). The authors calculated that research performance had among other factors a strong influence on relative income positions of academic economists. If an average faculty member is able to increase his research output - measured by the number of publications and weighted by the relative journal reputation¹ - to that of the top 15 percent, it could raise his annual salary by \$ 3.450. This corresponds to a rate of income growth of 18 percent.²

¹However this type of weights is not free of critique, s. Hawkins, Ritter, Walter 1973.

Similar results have also be found in a former study by Kristof, s. Morin (1966, p. 403).

However, this is still an idealized way of looking at public spending for research. In a more realistic world, we have to drop the assumption that issues are decided unanimously. Under unanimity rule, everybody has an incentive to be well informed on the issue because he casts the decisive vote by definition. But as soon as we depart from the unanimity requirement, the probability increases that one's vote has no effect on the result, and therefore voters have no incentive to be well informed. This gives room for the actions of interest groups. On the one hand there are scientists (professional staff of universities and students) who have a vested interest in increased spending and who seem to form a powerful pressure group (Staaf and Tullock 1973). On the other hand there is the greater number of poorly informed voters who may be reluctant to invest a great sum of money in long-term research projects the outcome of which is even more uncertain in their own view than in the view of the well informed scientists. The net result of the voting process remains uncertain with regard to its ability to generate a Pareto-optimal level of expenditures. It depends on whether the interest group of the scientists and students is powerful enough to convince the median or decisive voter to support an optimal (or even overoptimal) budgetary outlay for research.

IV A System of Honorary Decorations

Whatever the sum of money is which politicians assess for subsidizing research, the decision may be regarded unsatisfactory; for, as above explained,

the attainable payment scheme leaves few room for incentive creation and a lot of the expenditures are used up to give scientists the "insurance" of the tenure. As a way out of this limitation, it could be inquired whether a system of honorary decorations as applied in socialist countries for comparable reasons would be useful. We shall ask first whether at all a system of decorations would be of some help. Then, if positively answered we shall look how it should be organized.

The first question can be answered with little new information.¹ Decorations are certificates of the research quality of a scientist. Since this magnitude is not easily evident for everybody, decorations are informative instruments for ranking an individual within the scientific community. But simultaneously with the decoration, a researcher receives also the gift of "exclusiveness", viz. the visible lifetime membership within the informal club of the decorated people; for decorations are expected to be worn visually, at least at special events. Although decorations may have an influence on salaries, we do not concentrate here on that point. Our assertion is rather that the exclusiveness which decorations provide have an economic value per se. This implies obviously a serious measurement problem; but up to here it is only necessary to assume that this value is greater than zero. This hypothesis is supported by everyday observations. People spend a lot of money for goods and services

¹For some first theoretical foundations of that problem see Hansen and Weisbrod 1972.

to reach exclusiveness or, even more, to attain a degree of exclusiveness which other people already have. For example, a great deal of the post-war shift of the macroeconomic consumption function can be explained by such demonstration effects. If monetary expenditures for exclusiveness are obvious there exists no reason why scientists would not be willing to spend additional time in research to attain exclusiveness (assuming that scientific exclusiveness is a non-tradable good in money terms). We expect therefore that decorations yield an increased research output. But government's costs to obtain that output are zero (or nearly zero). Therefore the efficiency requirement for the decoration system is fulfilled even if the effect on output should turn out to be small. Given costlessness of decorations, the proposed system is expected to be supported unanimously by a rational citizenry. It could be argued, however, that non-decorated people are worse off. But the same objection could be made against additional money payments to successful scientists. Yet this positive shift in income distribution would not be regarded as a violation of the Pareto criterion.

There remains the problem of how the proposed decoration system should be organized in order to maximize the incentives for additional research. Two questions can be asked:

1. What level of scientific output should a decoration be granted for?
2. How many types of decorations should be granted?

The traditional view is that scientific output would be most induced if only few decorations are distributed and if these are designated for the highest levels of output. In economics, for example, we could mention the election to the presidency of the AEA, the Francis A. Walker Medal, the Distinguished

Fellowship, and to a lesser extent the John Bates Clark Medal. In order to test whether it is correct to concentrate awards on top level scientists, we should have some additional information on the measure of exclusiveness which influences the research output. We suppose that induced research per scientist is greater, the higher the degree of exclusiveness. The latter can be regarded by its proper definition as a declining function of the number of scientists who are expected to receive the decoration. Though that measure is not perfect it does tell us something on the amount of change of exclusiveness.

On the other hand, we can measure the natural distribution of intelligence per scientist from which the potential productivity of researchers can be derived. This potential output distribution is depicted in Figure 1 in a declining pattern from the left to the right on the abscissa (curve CD). The actual output is assumed to be a (constant) fraction of the potential so that the convex shape remains (curve AF under the given salary scheme [s. III above]).

If the necessary output to obtain a decoration is set at D_1 all scientists left of N_1 will be given a decoration without additional work. Some scientists having an output in the neighbourhood but right of N_1 will spend additional resources to attain the exclusiveness of being decorated (say e.g. $D_1 - D_2$). This is the effect of the above explained positive economic value of exclusiveness. Whether the researchers will succeed or not is uncertain, but they will increase their scientific output toward D_1 , and on the average additional research of about the shaded triangle I will be carried out. By lowering the necessary level of output to D_3 , more scientists

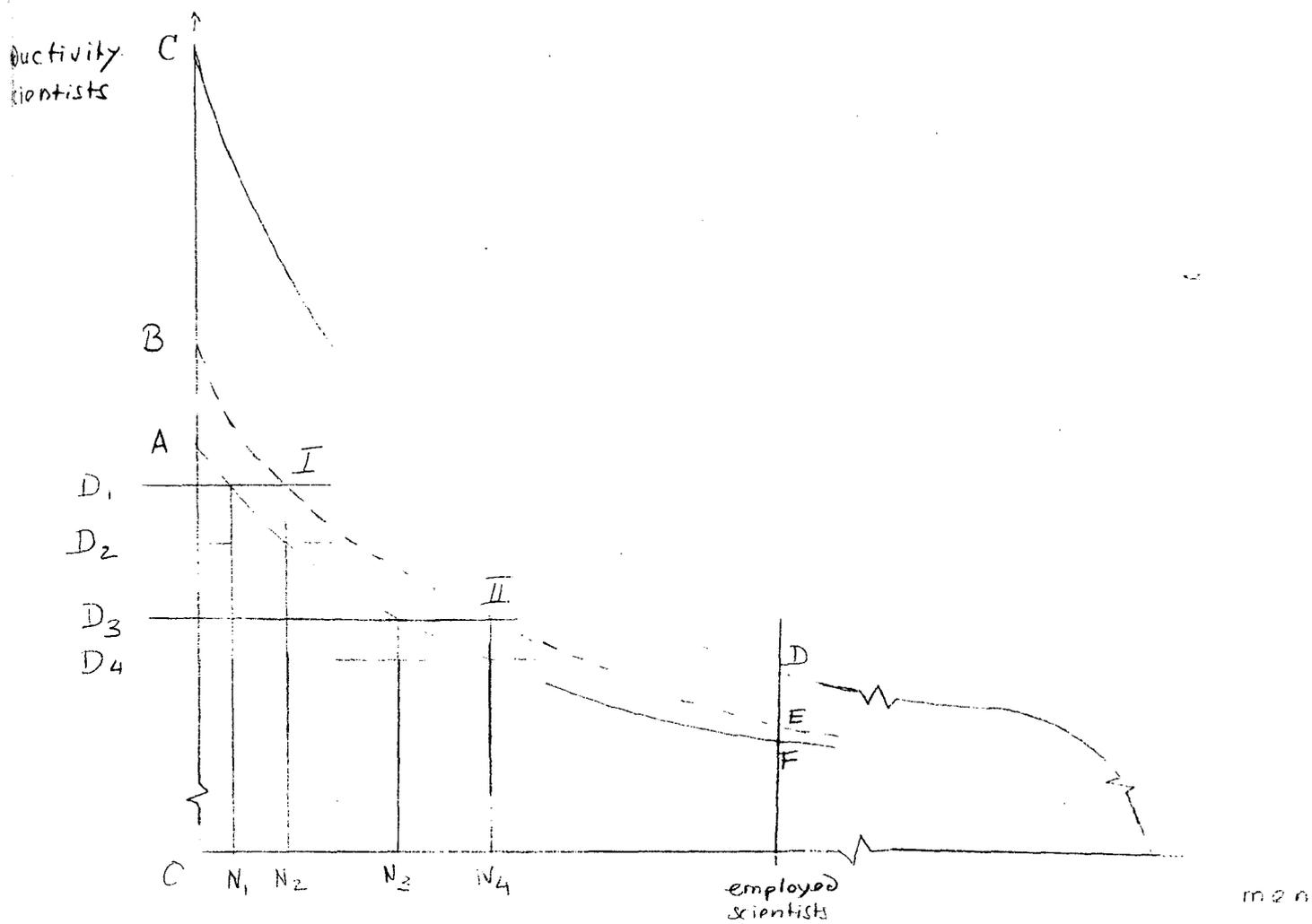


Fig. 1

will get the decoration anyway (N_2). Therefore exclusiveness and the amount of incentives generated per person declines. On the other hand the actual output curve becomes flatter and more individuals will be attracted to carry out research; so the triangle II will result. It cannot be said a priori whether triangle I or triangle II is greater. Given that amount of information on the measure of exclusiveness, there is no reason to concentrate granted decorations at the upper end of the scientific community. If the negative incentive effect of the greater number within the exclusive club is only small, it could be preferred to set the required level somewhere in the middle of the actual output range.

Up to here we have assumed that there are only decorations for one level of output. But decorations could be granted for different levels so far that every scientist could reach his preferred amount of exclusiveness. If all were equally keen on decorations the dotted line BE could be reached. But thereby we would enormously overestimate our capacity to measure and to evaluate different scientific outputs, and errors would be numerous. Such mistakes would certainly weaken the incentive effects of the decoration system. Moreover, a great number of nearly similar decorations would disguise the informative power of decorations. Given the limited human capacity to register different levels of awards, it may be rational to choose a magnitude near Miller's "Magical Number Seven" per academic discipline (s. Miller 1956 and Hirshleifer 1973). If the required levels of accomplishments were widely enough dispersed, this number might also meet our possibilities of more or less accurate output measurement.

Looking at the example of economics awards, we would conclude that the recent addition of the Distinguished Fellowship (1965) to the Presidency

and the Francis A. Walker award which are all designated for the most prominent accomplishments in economics was possibly not so efficient. It is hard to determine the quality distinctions between these three types, and therefore informative power is weakened or at least not increased. This does not mean that the number of granted awards should not be enlarged within the given types of awards. If new awards are to introduce it is probably more efficient to create speciality awards for different fields. These would lie relatively far away from the highest awards and from each other, and measurement is easier therefore. In some sense the John Bates Clark Medal meets the advantage of dispersion; for it is designated for economists of the age below 40 years.

V Conclusions

The paper has dealt with the recently raised assertion of overcompensation of researchers. By overcompensation is meant that inventors get for an additional invention more than the social benefit. Although overcompensation might occur by extraordinary speculation, it seems to be rather the exception. The free enterprise university system would reward scientists in some cases where property rights can be enforced. However many research results are public and therefore government spending for research seems justified. Yet within the constraints of incentive oriented payments, risk insurance, and "moral hazard", a system of decorations for successful research may be considered as a useful instrument to further research output.

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