Incentives for Entrepreneurship and Supporting Institutions

By

Richard R. Nelson

Contents: I. The Meaning and Role of Entrepreneurship. - II. The Capitalist Engine - Simple and More Complex Views. - III. Innovation Incentives, Technological Progress, and Industrial R & D Spending. - IV. Links with Science. - V. The Roles of Government. - VI. Reprise.

I. The Meaning and Role of Entrepreneurship

The term "entrepreneurship" has been used in a variety of somewhat different ways. In this essay I follow Schumpeter in defining entrepreneurship relatively narrowly as the carrying out of innovation. Thus I shall use the expressions incentives for entrepreneurship, and incentives for innovation, interchangeably.

But this only pushes the definitional problem back a stage. What does one mean by innovation? Schumpeter defined the term innovation against the backdrop theoretical concept of a circular flow of economic activity[1]. In this circular flow the actions of all the individual participants are taken routinely, even habitually. Schumpeter characterized these actions as consistent, and mutually supportive, in a sense closely akin to the characteristics of a general equilibrium of contemporary theory. Similarly, in Schumpeter's circular flow, as in a contemporary general equilibrium, the financial situation of the individual actors is viable, given each actor's objectives, so long as the other actors continue to behave in their routine ways.

Innovation is defined as a departure from behavior in the circular flow, taken by one of the actors. Schumpeter clearly viewed an innovative act, an act of entrepreneurship, as involving uncertainty, in a sense later spelled out by Knight [1921], and also as involving an element of creative idiosyncrasy. Entrepreneurship is seeing an opportunity that others may not see, or which others discount, and taking the plunge.

Above I have associated certain elements of Schumpeter's theory of the circular flow with the concepts of contemporary general equilibrium theory.

[1] This articulation is developed in his *Theory of Economic Development* [1934, a translation of his Theorie der wirtschaftlichen Entwicklung of 1912]. In his later *Capitalism, Socialism and Democracy* [1950], Schumpeter takes the position that innovation is the normal, indeed necessary, state of affairs in modern capitalism. However, the implicit concept of innovation, as involving elements of the "non-routine" is carried over.

It is tempting to try to draw the connections closely and, also, to treat recent neo-classical models that incorporate innovation as a formalization of Schumpeter's theory. However, I think this would be a mistake.

Neo-classical theory sees the economic actors, in a general equilibrium, as having available to them a set of actions, different ones being maximizing under different constellations of prices, and presumes that actors would have no trouble shifting from one to another in response to changed price incentives. In contrast, Schumpeter stresses the habitualness of behavior in the circular flow, implying that the range of activities that are firmly in mind is quite limited, and that there is likely to be considerable inertia. Schumpeter's theory of behavior in the circular flow is a "behavioral theory".

The neo-classical formulation sees choice sets at any time as being well defined and well known to all actors. The actor's problem is to choose optimally. In the recent models which treat innovation explicitly, a sharp disjunction is assumed between the presently available production set, and the set of additional production possibilities, innovations, that can be added to the former set, with the expenditure of time and effort[1]. However, innovation, like production, is visualized as choosing from a well defined set, with the elements obvious to all. There is room here for risk, but not Knightian uncertainty.

The neo-classical formalism does not encompass concepts like creativity, or insight, or genius. In contrast, the Schumpeterian formulation carries the aura that choice sets at any time are poorly defined, once one diverges from routine habitual behavior, and that different individuals see opportunities for innovation in different ways. There is a presumption that there are better ways to be doing things, and better things to be doing, but what these are is not transparent, they need to be discovered or invented, and tried out in practice. As Baumol [1968] observed some time ago, this is what entrepreneurship is all about. There is no room for this kind of thing in the neo-classical formalism.

Schumpeter, and many classical economists before him, clearly saw the economic problem, and the central economic processes drawn by market institutions, as involving experimentation, exploration, in an essential way. The appropriate experiments are not obvious, nor what will be found out, for the terrain is poorly charted, and sure to contain some surprises. There is much more to this view of the economic problem, and economic activity, than simply allocating resources to alternative activities and purposes, and making good (optimizing) choices.

Over the past decade Sidney Winter and I have been trying to develop an evolutionary theory of economic change that formalizes, or at least squares formally with, some of the basic Schumpeterian notions [see Nelson, Winter,

[1] While there are more recent discussions, I believe that the best general treatment of neo-classical modeling of innovation is contained in Binswanger and Ruttan [1978].

1982]. We have called our theory evolutionary. While Schumpeter explicitly eschewed the term, we would argue that his theory clearly was evolutionary, at least in the way that we have used the concept.

An advantage of our formulation is that innovation need not be understood against a background of a hypothetical steady state circular flow, but rather in terms of the introduction of a new way of doing things into the prevailing economic context, much more generally defined. In our formulation, and in the one we think Schumpeter had in mind, economic activity is always in a state of flux, and disequilibrium, with the system always in the process of winnowing out and selecting on past innovative efforts, at the same time that new innovations are being offered into the system for selection. When one looks at the economic problem from the perspective of evolutionary theory, economic progress depends on the quantity and quality of mutations (innovations) that are introduced to the system, and effectiveness of the processes that winnow the new departures, and spread those that are advantageous, and stamp out those that are not. We believe that this is the most fruitful vantage point for studying innovation and entrepreneurship.

While Schumpeter was concerned with innovation of a wide variety, his central focus was on technological innovation, and in what follows I will concentrate on that. In Section II, I first discuss the characteristics of incentives and institutions supporting innovation in capitalist economies as they are depicted in the Schumpeterian story and in most simple models of innovation. I then develop the point that the empirical reality differs from the simple models in several important respects. One of these is that there are a variety of different mechanisms by which innovation is induced and rewarded, and that these differ from sector to sector. This point will be developed and some empirical evidence brought to bear on it in Section III. A second point is that models of Schumpeterian competition tend to ignore science or deal with it in a superficial manner. I discuss this issue in Section IV. Finally, Schumpeter and recent models of Schumpeterian competition, tend to ignore the strong role played by government in many sectors. This is the topic of Section V. In Section VI I wrap up certain matters.

II. The Capitalist Engine - Simple and More Complex Views

There is a long standing tradition, within Western economics, of seeing a pluralistic, profit-motivated, and market-coordinated, economic system as a powerful engine for the generation of technological progress, and for the wide spreading of its benefits. Smith thought so. Marx lauded capitalism for these attributes, if not for others. And, of course, Schumpeter and more contemporary followers in his tradition also recognized these characteristics.

It should be apparent, however, that this belief has little grounding in neo-classical theory, but rather reflects some combination of empirical observation and verbal if abstract views regarding the conditions that stimulate or stunt technological innovation. Thus Adam Smith observed the faster rate of technological advance in Britain than in France, and argued that it was the freedom of individual British entrepreneurs (to use Schumpeter's term) to pursue their own ends as they saw them, compared with the more constrained business system in France, that lay behind the difference. Marx noted the remarkable surge of technological advance in the capitalistic era, and argued that the force of competition forced capitalists to innovate in order to survive. Schumpeter put forth something like this position in his *Capitalism, Socialism, and Democracy,* if not in his earlier *Theory of Economic Development,* in poiting out that the new product, or the new process, is the most effective means of competition in oligopolistic industries.

It is interesting that, in much of the writing extolling capitalism, there is an explicit or implicit presumption that a centrally planned and controlled system would not work as an effective engine of progress. Interestingly, Schumpeter, in *Capitalism, Socialism, and Democracy,* concluded that innovation was at the stage of becoming sufficiently routine and plannable that socialism would not be disadvantaged in that regard. Yet the socialist countries continue to struggle to devise a system that adequately supports and channels industrial innovation[1]. Technological advance continues to be an evolutionary and experimental process that cannot be planned in any detail. It is a great advantage to have multiple sources of innovation, and to rely on ex-post selection mechanisms to winnow the wheat from the chaff.

This is not to say that the capitalist engine as it has evolved is the best possible engine of progress. Indeed it almost surely is not. And the last decade has seen a large number of policies that have tinkered with it, and supplemented it, in a variety of ways, with the objective of making it work better. Economists have been called upon to help guide the development of policies. However, economists and other scholars have only limited understanding of how the current system actually works, much less where it works well, and poorly – and we are a long distance away from being able to prescribe how to make it work better.

Stylized models of Schumpeterian competition provide some guidance, but of a very rough variety. In Schumpeter's theory, and in the formal models of Schumpeterian competition that have been developed, the key actors are private business firms. The lure and reward for innovative activity, which is costly and may be risky, is the transient quasi-rents that will accrue to a firm if it comes up with a better technology than its competitors. In more complicated Schumpeterian models, as those Winter and I [1982] have developed,

[1] Berliner's essay [1976] on the Soviet system, its problems, and attempts at reform, is somewhat dated, but to my knowledge is still on the mark. The discussion of the topic by Khachaturov [forthcoming], suggests that the problem of reconciling central planning and innovation is far from being solved.

innovation may be profitable for a firm even if it does not put the firm at the technological forefront, so long as it enables it to reduce its own costs, or enhance its own profit margin.

There are three roughly separable classes of factors that determine incentives for innovation - the magnitude of the quasi-rents - within these models: technological opportunity, the size of the market, and the ability of an innovator to appropriate the returns from his initiative. Technological opportunity refers to what the R & D and other investments required for innovation in a field are likely to achieve. It is apparent that in some fields R & D is much more effective in coming up with significant advances than in others. The size of the market refers to the number of potential users of an innovation and how much each could benefit from its use. The ability of the innovator to appropriate returns refers to the profits the innovator can make from an innovation, as differentiated from the returns that will be snapped away by imitators, or will go to consumers since market power of an innovator is constrained initially, and is further eroded as competitors get in the act.

The first two factors are associated with the net social returns to innovation; the last factor is of a different standing. Potential net social returns will not be viewed as profit opportunities for private innovators unless there is reasonable chance to appropriate a certain share of the social gains. For the Schumpeterian engine to work well, generating innovation and spreading the benefits, there must be significant opportunities for transient quasi-rents, but these must erode over time. Good performance requires something of a balance. If quasi-rents are eroded too quickly, there is no incentive to innovate in the first place. If an innovation establishes a durable monopoly over a substantial piece of the market, the benefits will be passed on to consumers in only limited degree, and dynamism may dry up for lack of competitive pressure.

Even if there is reasonable balance, there are certain inefficiencies built into the basic design of the capitalist engine. The analytic and policy questions are not whether these kinds of "market failures" exist, because they surely do, but rather how serious they are, and, where they are serious, whether it is possible to remedy them without clogging the engine[1].

In the first place, there are trade-offs between static efficiency and incentives for innovation. To the extent that a firm gains profits from its proprietary technology by limiting its use, there is a "triangle" loss. Relatedly, if other firms are precluded from using the best available technology because it is proprietary, and are forced to use worse technologies, there are costs here as well. These costs would obtain even if industry is composed of a large number of relatively small firms, as in the picture Schumpeter drew in his *Theory of Economic Development*. In his *Capitalism, Socialism, and Democ-*

[1] The following discussion draws heavily on my article "Assessing Private Enterprise" [1981a].

racy, Schumpeter proposed that a market structure, involving a small number of firms, with sustained power to keep price in excess of cost, is the price that society must pay in order to gain sustained technological progress, in at least some industries. This is another kind of triangle cost.

Second, there are certain inefficiencies built into the innovative process itself. If firms have less than perfect ability to exclude other firms from using their technology, there is the well known "template externality"; other firms rake off some fraction of the economic advantages created through the activities of the innovating firm, and this reduces the incentives for innovation in the first place. On the other hand, if there are advantages of leading over lagging there are problems akin to those of multiple independent tappers of an oil field, or fishermen working in the same body of water. Too much innovative input may be attracted to certain fields, and that input may be allocated inefficiently, compared with a regime of more orderly and coordinated exploration. More generally, given a set of established patents and imperfect license markets, individual companies can make money from projects that would not be worthwhile had they access to the best technologies developed by others.

There are, third, some potential problems in the capitalist system that stem from the cumulative characteristics of technological advance. Sometimes what is learned in one inventive effort provides strong clues as to where and how to look next. Sometimes a new technology itself provides a basis for further development. The proprietary nature of the particular technique, and of technological knowledge in general, then hinders not only the ability of other firms to use this technique and knowledge in production, but to use them in R & D as well.

As stated, these "market failures" are not simply artifacts of a particular theory. There is evidence, at least of a qualitative and anecdotal nature, for every one of them. But we do not know how costly they are. And I would argue that identification of market failure alone is of limited use in guiding policies to make the Schumpeterian engine work better. It may be much easier to point to blemishes than to design public policies that are effective in dealing with them.

The simple models of Schumpeterian competition provide a start on analysis of "incentives" for innovation, but only a start. There are several matters these models do not deal with adequately, or even repress.

In the first place, there is every reason to believe that the picture differs significantly from industry to industry. Technological progress has been rapid in some, slow in others. Various studies suggest that these differences can be explained, in part at least, by the intra-industry pattern of R & D expenditure. In turn, the allocation of industrial R & D surely reflects the incentives for "innovation" in different industries. While this is generally recognized, it is less well known that the key mechanisms enabling an innovating firm to reap returns differ from industry to industry, and so also the factors affecting technological opportunity. I address these issues in the following section.

Second, almost surely one reason for the observed differences in rate of technological progress is that the links to science are stronger in certain technologies than in others. When these links are strong, this is in good part because of the presence of bridging applied sciences, and institutions supporting these. The applied sciences and their supporting institutions have been virtually ignored in most economic analyses. I discuss them in Section IV.

Finally, Schumpeter was peculiarly blind to the widespread and important, if varied, role of government R & D support for industrial innovation, and most extant models also ignore government R & D funding. Section V attempts to describe different kinds of government programs in support of industrial innovation.

III. Innovation Incentives, Technological Progress, and Industrial R & D Spending

The half century between Schumpeter's writing of his *Theory of Economic Development*, and the writing of *Capitalism, Socialism, and Democracy*, was marked by the rise of industrial R & D, linking institutionally invention and innovation. Much ink has been spilled about the role that freelance inventors, and entrepreneurs, continue to play in industrial innovation, but virtually no knowledgeable person denies that industrial R & D now accounts for the lion's share of the story in most technologically progressive industries[1]. So, today, incentives for entrepreneurship can be seen as reflected, to a considerable degree, in the magnitude and allocation of industrial R & D spending.

As noted, the standard indices of technological progress vary significantly across industries. A number of studies have shown that a good share of the differences can be explained by differences in R & D spending in an industry, and by upstream suppliers.

To what extent can the observed pattern of R & D expenditure be explained by the strength of incentives for innovation in different lines of business? To probe this question and related ones, a group of us at Yale designed a questionnaire which we sent out to R & D executives in a large number of lines of business[2]. The basic conceptualization behind the questionnaire was drawn from the logic of recent models of Schumpeterian competi-

[1] I do not mean to downplay here the role of new, often small, business in innovation in a number of fields, particularly when new technologies are just opening up. However, the conclusions reached by Jewkes *et al.* [1969] in their classic study have been qualified significantly by recent work [see Nelson, 1981b].

[2] A more complete report on the findings of the questionnaire should soon be available in Levin *et al.* [1984].

tion. As indicated earlier, within these models, given the overall size of the market for the products of an industry, R & D spending is related to two different kinds of variables. Other things being equal, R & D spending will be larger the more important the advance likely to be won by spending a certain amout on R & D, and the greater the share of value added created by an innovation that can be seized by the innovator. Our questionnaire has given us a wealth of information about technological opportunity, and about the strength and character of the mechanisms by which firms appropriate returns from their innovations in different lines of business. We have only just begun to analyze the data, and what I report below should be regarded as a very preliminary preview of coming analyses.

I shall begin by reporting our findings about appropriability. There are two important findings that emerge clearly. First, there is a variety of different mechanisms that are employed. Second, there are strong inter-industry differences in the mechanisms that are central for reaping returns, and also some systematic differences between incentives for product and process innovations.

While most of the popular discussion about means of appropriability has focused on patents, according to the replies to our questionnaire, across the response group as a whole the advantages of a headstart, and running down the learning curve, were deemed more important (on average) as a means of profiting from both process and product innovations. For process innovation, but not product, secrecy was judged more important than patent protection. For product innovations, less so for process innovations, strong sales and service efforts were judged very important. These responses are not surprising. A number of earlier studies indicated that patents were of major importance in only a few industries. And it long has been recognized that process technology is easier to keep secret than technology embodied in a product which is sold to anyone who wants to buy. Also, if a firm finds a way to improve its own processes, it well may want to shield its innovation, not sell it to its competitors. But the results here are from a larger sample, and are more systematically collected, than earlier results.

Patents seem to be important mainly in the industries based on chemical technologies, and especially pharmaceuticals, and in industries producing simple mechanical devices. The industries that rated patents as effective also reported that patents significantly increased the cost and time it would take for an imitator to respond with a comparable product or process. In industries like pharmaceuticals, where apparently reserve engineering is easy technically, imitation would be cheap and quick without patent protection. With patent protection that blocks simple duplication, imitation costs and lag are significantly increased.

Patents were judged of significantly less importance in industries based on electrical, and complex mechanical, technologies. In semi-conductors, and computation equipment, a headstart, together with learning curve advantages, pushed by a strong selling effort, were the dominant mechanisms for reaping returns from both product and process innovation. In the aircraft industry, these mechanisms also were of considerable importance, and patents were not rated as counting for much. However, for aircraft and communications equipment, it was about as expensive to reverse engineer a product as to create it in the first place, even if there were not blockages provided by patents. This was so for process innovations in a number of industries.

As noted, a principal purpose of our questionnaire was to see if the R & D intensity of an industry can be at least partially explained by the ability of firms in that line of business to appropriate the returns to an innovation. R & D intensity was, in fact, quite strongly positively correlated with the reported effectiveness of the various appropriability variables.

We had to probe more indirectly at factors behind technological opportunity in different lines of business. One set of questions asked about the importance of various fields of science to an industry's technology. It is not surprising, but nonetheless comforting, that the industries whose technologies are generally regarded as "science based" tended to report strong connections with one or more fields of science. The R & D intensity of an industry was positively correlated with various measures of the reported strength of connections with science.

Another set of questions probed at the contributions of organizations outside a firm's line of business. A number of industries reported that suppliers of equipment, and suppliers of research equipment, played an important role. For some industries customers played an important role in facilitating technological innovation. Our preliminary regression run shows a positive correlation between process oriented R & D done in a line of business and the reported role of equipment suppliers. Product R & D was positively correlated with the strength of the role of customers.

We asked our respondents to judge the speed of product and process innovation in their lines of business. The reported rate of product innovation in a line of business was positively correlated with R & D done by firms in that line of business, the strength of the role played by equipment suppliers, and the role of customers. The perceived rate of process innovation was positively correlated with the first two variables above. This result is consistent with, but goes beyond, the positive correlation of growth of total factor productivity, with industry and upstream R & D, that has been found in a number of other studies.

All of this is very preliminary. The data set is rich, and the underlying structural relationships undoubtedly very complex. However, our probe to date suggests that, when suitably analyzed, the data from the questionnaire may shed a considerable amount of light on the structure of "incentives for entrepreneurship".

IV. Links with Science

As noted, an important part of the probe at technological opportunity was directed towards exploring links with science in different lines of business. Many of the sciences we listed are the generally recognized basic sciences, like physics, or biology, which go on largely in academic departments by those names in universities. However, we listed as well a number of "applied sciences", like metallurgy, and computer science, and the engineering disciplines. Analysts of technological progress have long been aware of the importance of the basic sciences to industrial innovation. By and large the picture presented has been of technological innovation drawing on findings in the basic sciences, with progress in the latter proceeding more or less autonomously. There has been far less recognition of the role of the applied sciences and engineering disciplines. Yet, by and large, the reported strength of the links to the applied sciences and engineering were greater than those reported to the basic sciences.

The applied sciences and engineering, and the nature of their institutional structures, reflect an accommodation to the fact that technological knowledge has a public as well as a private aspect. The public part of technological knowledge generally does not relate to the design or operational details of a particular product or process, but to "generic" knowledge - broad design concepts, general working characteristics of processes, properties of materials, testing techniques, etc. Such knowledge often is not patentable. While such knowledge sometimes can be protected by industrial secrecy, this may be difficult. Also, this is the kind of knowledge that must be imparted to those trained to be industrial scientists, engineers, or advanced technicians. Therefore, it would seriously interfere with the ability of technical schools, and universities, to provide good training if the relevant knowledge were proprietary.

Research in the applied sciences is conducted by scientists and engineers in industry, as well as at universities. For some large firms, such work justifies its costs in enabling the firm's design and development efforts to be a step more advanced than otherwise would be the case. In some fields, as now seems to be the case in certain areas of semi-conductor and computer technology, the industrial R & D groups may be doing more advanced work than the academics; in other cases industry based research is conducted largely to provide a window into academic research. But, in any case, good communication between industrial scientists and academic scientists is an important part of the enterprise. The journals generally receive contributions from both. The scientific societies include both.

A number of scholars have recognized that the alleged autonomy of the basic sciences has been overdrawn. Thermodynamics, as a field of physics, came after the advent of the steam engine, not before, and was motivated both by a desire to understand what was going on, and to facilitate design improvements. Pasteur's life work illustrates vividly the intertwining of intellectual interests and practical problems in determining the questions driving biological research. That solid state physics attracted a surge of new funds and new scientists after the advent of the transistor is not surprising.

However, the applied sciences and engineering disciplines represent an explicit and self-conscious linking of science and technology. Very often their academic home is not in the colleges of arts and sciences, but in professional schools like engineering, medicine, agriculture. The bulk of business support of academic research apparently goes to them, rather than to the regular basic departments. These disciplines might be considered "bridging" ones in that their ends tend to be defined by the technologies, while their means are often found in the basic sciences. And they are consciously constructed and supported with both ends of the bridge in mind.

I offer the following as a tentative generalization. Industries marked by unusually rapid technological advance tend to be supported by strong bridging applied sciences. This conjecture is well supported by the responses to the Yale questionnaire.

This raises the interesting question as to why certain technological fields have strong applied sciences and other not. A simple answer is that some technologies are innately closer to science than are others. However, this answer tends to downplay that links to science are to a considerable extent forged by an applied science, rather than being innate. A second answer is that firms in certain lines of business have recognized the importance of applied science, have worked to establish and maintain them, and serve as a market for their students and their research. Thus the chemical industry, first in Germany and later in the United States, strongly supported the rise of academic applied chemistry departments. A third answer is that government funds have strongly supported the development of certain applied fields.

V. The Roles of Government

In view of the fact that, in the major capitalist nations, governments generally account for from 30 to 50 percent of total R & D spending, it clearly is a mistake to analyze "incentives for entrepreneurship" without considering the government's role. It is somewhat surprising that Schumpeter had so little to say about this. Even before he wrote *The Theory of Economic Development*, the German government had been busily engaged in supporting the development of research institutions, and links between them and the German chemical industry. By the time he was writing *Capitalism, Socialism, and Democracy,* the United States government was playing a widespread role in supporting industrial innovation, directly and indirectly. The National Advisory Commission on Aeronautics had been established and was providing significant assistance in the design of aircraft. The army was supporting research that led to the development of the modern computer. The National Institutes of Health had been established. The history and analysis of the evolving roles of government in support of technological innovation is a vast topic, and I shall here only be able to chart portions of the terrain. Also, I shall limit myself largely to the U.S. scene[1].

While the lines between them are blurry, I have found it analytically useful to think of three somewhat different roles that governments have played. One of these is support of the basic and applied sciences, and scientific and technical education. A second is associated with procurement, generally national security interests. Finally, and of growing importance, governments have deliberately and broadly promoted the commercial technological competences of certain industries.

The role of government in support of the basic and applied sciences, and education, goes way back, and in the United States the major early thrust was through the land grant colleges, concerned with the agricultural and mechanical arts. However, the contribution of government to university research support, and scientific and technical education, experienced a quantum leap in the years after World War II.

In the United States, as in most other countries, a considerable portion of university research and training support comes through a general agency dedicated to those purposes - the National Science Foundation (NSF). However, the NSF never has accounted for more than one third of government support for university research and education. The bulk of the support is channeled through agencies with an interest in certain fields - the Department of Agriculture, the National Institutes of Health, the Atomic Energy Commission, the Department of Defense. It is interesting, and somewhat peculiar, that the role of mission oriented government agencies in supporting academic research and teaching, tends to be overlooked in many accounts of the role of government. However, the lion's share of government academic support has been focused on fields of particular interest to government agencies.

Some paragraphs before, I raised the question as to why certain technologies had strong applied sciences under them, and suggested that one of the reasons was that government funding had focused on certain applied fields, but not others. Above I have described the mechanisms by which that has happened. The story of the role of government in consciously molding the structure of the applied sciences would be a fascinating one to tell in some detail.

The procurement interests of government, principally, but not exclusively, national security related, have had an effect on industrial innovation that goes

[1] Much of the following discussion is drawn from Nelson [1982].

far beyond the differential support of various fields of applied sciences. Government agencies have long been an important part of the market eyed by entrepreneurs. The 19th century development of steel technology, and of organic chemistry, was profoundly influenced by the awareness of inventors, and entrepreneurs, that there was a large military market for better guns, armor, and explosives. There also was then a modest amount of direct government subsidy of research and development. In the post World War II era the strength and profitability of government procurement demands, and the amount of direct R & D support aimed at meeting those demands, increased enormously, not only in the United States, but in other countries that had maintained a large military establishment. While the government's interests have been technology and hardware for its own use, technological efforts thus drawn and thus supported have very widespread "spillover". Power reactors, jet engines and passenger jet aircraft, integrated circuits, the modern computer, and a range of materials now used in a wide variety of products, originally were induced by entrepreneurial perceptions of a defense demand, and often with government R & D support.

My remarks above are no news. However, it is remarkable how often economists' analyses of incentives in support for industrial innovation ignore the massive role of defense procurement, at least in the post World War II period.

While the lines are blurred, I think it analytically convenient to distinguish between government R & D support policies directly tied to procurement interests, and government policies which aim to establish or preserve a competitively strong industry. The reason the lines are blurred is that, in many cases, the industries which have received special government R & D support, or other benefits aimed to enhance technological competence, have been once deemed important to national security. Thus, since shortly after World War I, the United States has supported the American airframe and air engine industries with a variety of measures loosely connected, or not connected at all, with particular procurement objectives. In the post World War II era, the government adopted an explicitly promotional role regarding civilian nuclear power. There are many other examples.

Governments also have a tradition of promoting technical change in an industry when there has been a powerful political constituency who have wanted such support. The long standing public support of agricultural research is probably the most striking example. However, another good one is support of research on diseases, their preventions, and their cures, which also has a long tradition in the United States.

Over the last decade and a half there has been a vast increase in government R & D support programs expressly directed to helping an industry achieve a competitive position on international markets. The R & D support programs of MITI are well known examples. So also the SST debacles in

Europe, and the United States, and the more recent relatively successful European venture regarding Airbus. In another place I have examined these programs at some length, and do not have the space to do so here [see Nelson, 1984].

VI. Reprise

The first part of this essay was concerned with developing a picture of the economic problem and economic processes such that entrepreneurship and innovation made sense. I went on to discuss the incentives for entrepreneurship, within simple Schumpeterian models. I noted that, to the extent that the Schumpeterian picture is basically the right one, as I think it is, while entrepreneurial activity in capitalist systems may be energetic, and sensitive to variables on both the returns and the cost side that reflect social values, in no way can this system be considered "optimal" in the standard use of that term.

However, Schumpeter never claimed optimality. He, as Marx before him, simply noted that the capitalist engine was a remarkable generator of technological progress. To tinker with it to make it work better requires a sophisticated understanding of how it works, where it works well and badly, and why. I went on to report information describing very considerable interindustry differences in how the system works. A lesson I would draw is that we need to think of several different kinds of models of Schumpeterian competition, and learn which applies where.

In the last two sections I discussed additional complexities. I pointed out the importance of the applied sciences to innovation, and the role of the universities. The government is playing an increasingly important role, or I should better say roles. These facts lead me to conclude that we must think beyond the simple Schumpeterian model or models.

While perhaps three decades ago analysis of "incentives for entrepreneurship" could have focused largely on for-profit business firms, operating in civilian oligopolistic markets, to do so today would be to miss a good part of the action. The institutional structure supporting industrial innovation these days must be understood as very complex. Analysis of the incentives for entrepreneurship must learn to encompass that complexity.

References

Baumol, William J., "Entrepreneurship in Economic Theory". *The American Economic Review,* Papers and Proceedings, Vol. 58, 1968, pp. 64–71.

Berliner, Joseph S., *The Innovation Decision in Soviet Industry.* Cambridge, Mass., 1976.

Binswanger, Hans P., and **Vernon W. Ruttan,** *Induced Innovation: Technology, Institutions, and Development.* Baltimore 1978.

Jewkes, John, David Sawers, and **Richard Stillerman,** *The Sources of Invention.* 2nd edition. New York 1969.

Khachaturov, Tigran, "Incentives in the Soviet Economy". Paper presented to the Conference on Economic Incentives, held at the Institut für Weltwirtschaft, Kiel, June 18-22, 1984. Forthcoming in the Proceedings, to be published by Macmillan, London.

Knight, Frank H., *Risk, Uncertainty, and Profit.* Boston 1921.

Levin, Richard C., Alvin K. Klevorick, Richard R. Nelson, and **Sidney G. Winter,** *Survey Research on Technological Opportunity and R & D Appropriability: A Preliminary Report of the Findings.* 1984, mimeo.

Nelson, Richard R. [1981a], "Assessing Private Enterprise: An Exegesis of Tangled Doctrine". *The Bell Journal of Economics,* Vol. 12, 1981, pp. 93-111.

- [1981b], "Competition, Innovation, Productivity Growth, and Public Policy". In: Herbert Giersch (Ed.), *Towards an Explanation of Economic Growth.* Symposium 1980, Tübingen 1981, pp. 151-179.

- **(Ed.),** *Government and Technical Progress: A Cross Industry Analysis.* New York 1982.

-, *Policies in Support of High Technology Industries.* Yale University, ISPS Working Paper, No. 1011, Revised, New Haven, July 1984.

-, and **Sidney G. Winter,** *An Evolutionary Theory of Economic Change.* Cambridge, Mass., 1982.

Schumpeter, Joseph A., *The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle.* Translated from the German by Redvers Opie. Cambridge, Mass., 1934.

-, *Capitalism, Socialism, and Democracy.* With a new Preface. 3rd Ed., New York 1950.

* * *

Zusammenfassung: Anreize für unternehmerisches Handeln und Institutionen zur Unterstützung von Innovationen. - Zunächst analysiert der Artikel Sinn und Bedeutung von unternehmerischem Handeln und, was hier in der Schumpeterschen Betrachtungsweise auf dasselbe hinausläuft, Innovationen im Wirtschaftsleben. Dann folgt ein Bericht über vorläufige Ergebnisse einer Fragebogenaktion der Universität Yale, mit der erforscht werden soll, wie sich die Unternehmen die Früchte ihrer (erfolgreichen) Innovationsanstrengungen zu eigen machen und wie wirksam solche Formen wie z. B. Patente und schneller Verkauf neuer Produkte sind. Dabei zeigen sich erhebliche Unterschiede zwischen den Industrien. In den beiden letzten Abschnitten werden institutionelle Strukturen untersucht, die den Innovationsprozeß in den Unternehmen tragen und unterstützen. Die Bedeutung der angewandten Forschung für technische Neuerungen wird ebenso herausgestellt wie die für viele Industrien wichtige Rolle der Universitätsforschung.

*

Résumé: Incitations pour les entrepreneurs et des institutions qui supportent l'innovation. - D'abord l'article analyse la signification et l'importance des entrepreneurs et de leurs innovations pour l'activité économique. La perspective développée ici est fondamentalement Schumpeterienne. Après, on donne un rapport sur des résultats préliminaires d'un questionnaire de Yale désigné à explorer les formes principales qui sont appliquées à s'approprier des rendements d'une innovation dans des industries différentes et qui doit explorer l'efficacité de telles formes. Il y a des différences interindustrielles très considérables. Enfin, l'article explore des dimensions différentes des structures institutionnelles qui supportent la production des innovations. L'auteur souligne l'importance des sciences appliquées pour l'innovation aussi bien que le rôle vital joué par la recherche universitaire dans beaucoup d'industries.

*

Resumen: Incentivos para el empresariado e instituciones de apoyo. - La primera parte de este ensayo se ocupa de analizar el significado e importancia del empresariado y la innovación en la actividad económica. La perspectiva desarrollada es básicamente Schumpeteriana. La segunda parte da cuenta de los resultados preliminares de un cuestionario de Yale que tiene el fin de explorar los principales mecanismos usados para apropiar retornos de una innovación en diferentes industrias y su efectividad. Hay diferencias inter-industriales muy considerables. La tercera y cuarta parte del ensayo exploran varias dimensiones de estructuras de apoyo institucionales. Se destaca la importancia de las ciencias aplicadas para la innovación así como tembién el rol vital que cumple la investigación universitaria en muchas industrias.