Book Reviews

The Allocation of Resources to Invention

Since the mid-1950's there has been a significant increase in research on technical change undertaken by economists. This surge of interest has had many causes, but probably the most important has been a growing awareness among professional economists that existing formal and quantitative explanations of growth of output per worker are grossly inadequate. It has been clear to many that existing analysis of technical change is particularly weak and that a much deeper understanding of that subject is required.

Over the past decade research has been aimed at three objectives: to measure the effect of technical change on productivity and other economic variables, to relate the rate and direction of technical change to the quantity of resources allocated to various activities and purposes, and to identify the factors that determine the quantity of resources directed to achieving various kinds of technical advances. This research is beginning to bear fruit. A considerable number of articles and books have begun to appear which greatly increase our understanding of the process of technical change and its role in economic growth.

Jacob Schmookler has been probably the most influential researcher working toward the third objective mentioned above. His research has been directed toward illuminating what determines the allocation of resources to inventing in different fields. Now in **Invention and Economic Growth** (Harvard University Press, Cambridge, 1966. 352 pp. $9.95) he draws together and significantly adds to his previously published results. The product of a decade of research, the volume represents a major accomplishment and provides what almost certainly will be for some time the best explanation we have of the allocation of inventive activity. It should be of major interest to the scientific and intellectual community as a whole as well as to professional economists.

The raw data with which Schmookler has worked are patent statistics, in time series and cross-sectional. Recognizing fully the great heterogeneity of patents, Schmookler has built a sophisticated conceptual and empirical case demonstrating that the number of patents taken out at one time relative to another or in one field relative to another often can be used as a reasonably good indicator of the relative amount of inventive resources which were being applied. By using patent statistics as an index of inputs applied to invention in the relevant circumstances, Schmookler is able to consider much longer periods of time and wider and more detailed cross sections than if his research were limited by the availability of direct input data per se. His analysis of the meaning of patent statistics is interesting in itself. He shows that where we have independent input measures they are reflected in patents taken out; thus a quite close relationship exists between the rate of patenting and R&D spending or the number of scientists and engineers in a firm or industry. He also shows that patents are not meaningless pieces of paper which happen to correlate with inputs; it would appear that a much larger percentage of patents (about 50 percent, according to Schmookler's data) are actually used in practice than many people have believed. I have been convinced by Schmookler that in a wide set of circumstances patents taken out are a reasonable, if rough, indicator of inventive activity.

The central question to which he has given his attention over more than a decade is: how can one explain the observed variations over time, and differences between sectors at a given time, in patenting? As an economist, Schmookler naturally looks at this question in terms of demand factors, such as the size of the potential market for the invention, which influence the gross rewards should it be accomplished, and supply factors, such as the state of relevant scientific knowledge, which influence the costs of inventing and the chances of success. (Sociologists studying invention have tended to make a similar conceptual split among factors, considering social need and social capabilities.) To explain changes it is necessary to show that either conditions of demand or conditions of supply have changed. The principal conclusion Schmookler has reached is that variations in demand have had a far sharper effect on the allocation of inventive effort than changes in conditions of supply.

Schmookler backs up this conclusion with two kinds of evidence. The first is evidence from time series of patents in particular product fields. He argues that, to a first approximation, the rewards to (the demand for) a successful invention should be proportional to the sales of the product or product class in which that invention is incorporated. He then shows that in the industries he has studied, variations in the yearly rate of patents taken out on a product tend to follow closely variations in the sale of that product. Thus in periods when the railroads were purchasing a great deal of equipment, patents taken out on railroad equipment were numerous; when equipment purchases were small the patenting rate was less. When purchases of equipment rose, so did the patent rate, with a lag; when purchases fell, so did the patent rate, with a lag. The evidence of the lag is important to Schmookler's case, for it weakens the argument that the causation is the other way round. Furthermore, not only do patents on railroad equipment in general tend to follow movements in the sales of railroad equipment generally; patents on the various components of railroad equipment—brakes, vehicles, engines—tend to move together with the sales of the equipment in which they are embodied. Since it is unlikely that changes in capability of inventing in all the component fields should be very highly correlated, this not only is positive evidence of the importance of changing demand conditions, but also evidence that changing relative conditions of supply have not been very important in determining patenting.

The cross-section evidence is even more impressive. Schmookler has collected data for several postwar years, and covering a wide range of industries, on patents relating to the capital equipment of an industry. The distribution of patents taken out on capital equipment for different industries almost exactly matches the distribution of equipment purchases. Changes in the distribution of patenting lag but cor-

relate well with changes in the distribution of equipment purchases. Schmookler has attempted to extend his cross-section analysis to earlier years (for which capital-investment data by industry are not available) by using value added as a proxy for investment. His results are consistent with those above, but of course the fit is far less good. Thus cross-section data, like time-series data, reveal the powerful influence of the size of the market on the allocation of inventive effort.

To complement statistical evidence, studies were undertaken by Schmookler and his graduate students of 900 specific inventions in the petroleum refining, paper, railroading, and farming industries in order to try to identify whether demand factors or supply factors played an important role. Often it proved impossible to identify the conditions that led to the inventive effort. However, while in many cases Schmookler and his fellow researchers did find clear-cut evidence that changes in demand or new awareness of demand triggered an inventive effort, no clear-cut case was found of a scientific advance that triggered an effort to exploit it. Schmookler acknowledges that there may be cases in other fields of invention in which increased capability was the dominant initiating factor, but suggests that these must be in a minority relative to demand-induced inventive efforts.

Schmookler's conclusion is that the vast changes in the allocation of inventive effort that have occurred over the long run, and the changes that are occurring in the shorter run, are quite well explained by changes in the pattern of demand for goods and services. As demand patterns have shifted, so has the pattern of inventive effort. In comparison with the great explanatory power of demand shifts, changes in the relative costs and capabilities of inventing in different product fields appear to have had only a minor influence.

Schmookler has some sensible and interesting things to say regarding the reasons for this. He suggests that the nature of scientific advance has had its major influence in determining the magnitude and precise character of the technical advances we have achieved, not the *product* fields. Over the years a growing percentage of patents have been taken out on electrical as compared with mechanical devices; this clearly is the result of the improved capability of inventors to make these kinds of inventions. However, electrical devices have been relevant to the products, processes, or equipment of almost every industry. To a first approximation it would appear that inventors (and those that hire them) pick the product field and problems on which they work largely on the basis of considerations relating to demand, with the stock of knowledge (like knowledge of electricity and the technology of electrical apparatus) influencing the technical nature of the design solutions tried and achieved. Thus, as the United States spread out geographically, the returns to significant improvements in long-range communications systems sharply increased, and as a reflection of this many inventors were attracted to the field. The early systems were principally mechanical. The advance in knowledge of electricity opened up a variety of new approaches and permitted the achievement of a system representing orders-of-magnitude improvement over mechanical systems. But inventors had begun flocking to work on both systems long before the advances in scientific knowledge occurred which permitted major advances to be achieved.

Schmookler also has some interesting data and things to say about individual versus corporate inventors, the reasons for the decline in the patent rate per scientist or engineer in the postwar era, patent performance of big companies versus that of small companies, and issues relating to the "mining out" of a field. But the major thrust of this book is to present and develop the impressive evidence for the demand theory of the direction of invention. The book is a major intellectual and scholarly accomplishment.

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Broad-Scale Psychiatry

The Group for the Advancement of Psychiatry (GAP) was founded in 1946 by a group of outstanding physicians in response to their frustrations as military psychiatrists during World War II. More than 2,500,000 men had been either rejected or discharged from the armed forces because of emotional disorders. The traditional patterns of selection of men for military duty as well as the techniques for prevention and treatment of mental illness seemed lamentably inadequate to the psychiatric needs of the nation. GAP was started accordingly with the express purpose of seeking to improve the quality of psychiatrists' contributions to national mental health planning as considered in the broadest possible social frame of reference. It has developed as a loose federation of specialized committees, 21 in number, each functioning as an investigative team. Membership is by invitation, and every member is a collaborator in a selected project. The assembled committees meet twice a year to discuss work in progress.

When the members of a committee have completed a study they formulate a draft of their findings for consideration by other GAP members. The final published report represents the total group consensus. GAP committees also arrange symposiums in which members and invited nonmember experts participate. If the quality of the proceedings is particularly high they are published. In this way GAP has published 58 reports and the proceedings of ten symposiums since its inception. **Psychiatry and Public Affairs** (Aldine, Chicago, 1966. 479 pp., illus. $8.95) consists of a selection of these reports and symposiums which provide the reader with an opportunity to sample the work of GAP and to acquaint himself with its general mission, and which may perhaps stimulate him to study its work *in extenso*.

The book opens with a statement entitled "The social responsibility of psychiatry." Originally published as report No. 13, in July 1950, it calls for a redefinition of the concept of mental illness so that the main focus of psychiatrists will be on the zone of contact between the individual and his society. The report recommends a study of the social factors which contribute to the causation of mental illness and which influence its course and outcome. "Specifically, we favor the most intensive study of the psychosocial factors influencing human welfare. We favor the application of psychiatric principles to all those problems which have to do with family welfare, child rearing, child and adult education, social and economic factors which influence the community status of individuals and families, inter-group tensions, civil rights and personal liberty. . . . This, in a true sense, carries psychiatry out of the hospitals and clinics and into the community." The only exception one might take to this admirable statement of principle is its too exclusive emphasis on mental illness. The noxious psychosocial setting which breeds mental ill-