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DIFFUSION OF TECHNICAL INNOVATION

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CHRISTOPHER FREEMAN

UNIVERSITY OF SUSSEX

SCIENCE POLICY RESEARCH UNIT

FALMER, BRIGHTON, SUSSEX, UK

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13. ABSTRACT

Project SAPPHO (Scientific Activity Predictor from Patterns with Heuristic Origins) analyzed the innovative sequence in industry. SAPPHO was designed to test explanations of success and failure in industrial innovation. Fifty pairs of similar innovators were selected, each consisting of a "success" and a "failure", and data collected to determine factors bearing on their success or failure. Key factors were found to include: better understanding of user needs; greater attention to marketing; more efficient development; more effective use of outside technology and advise; and greater seniority and authority of responsbile officers.

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Project SAPPHO (Scientific Activity Predictor from Patterns with Heuristic Origins) was conceived at the Science Policy Research Unit, University of Sussex, as a means of analysing the innovation sequence in industry. The main sponsor was the Science Research Council but in addition a travel grant was received from the Department of the Air Force to enable overseas interviews to be undertaken. The first phase of the project has now been completed and a report was presented to the SRC in October, 1971 (a copy has been sent to the Department of the Air Force).

Initial work on the project involved the systematic scrutiny of the previous literature on innovation, and the preparation of a card index of references and abstracts of important works. This revealed that there had been little or no previous study of failures in industrial innovation. It also indicated that there was a strong mythologising process in relation to case studies of successful individual innovations and biographies of inventors. SAPPHO was, therefore, designed with these factors in mind to test possible explanations of success and failure in innovation. The hypotheses relating to success were partly those advanced in the literature and partly those generated in previous studies of innovation carried out in the Unit and at the National Institute of Economic and Social Research. A basic assumption of the project is that typically more than one firm is involved in attempting a product or process innovation for the world market, and, therefore, that it should be possible to select and compare a success (in terms of market share primarily) and a failure from this group.

Among the many hypotheses which SAPPHO was designed to test were those relating to the organisation and size of R and D departments; to the communication system within the firm; to methods of project evaluation and project management; to links between research and marketing, or between the firms and its customers; to the profitability of firms and their size; to their external relationship with other scientific and commercial organisations; and to the career and educational background of innovators and entrepreneurs.

The method of data collection began with the discovery and selection of "comparison pairs" of innovations in areas of similar or identical technology but intended for identical markets. Each pair consisted of a relative "success" and a relative "failure", the usual criterion of success being market penetration (quantified in percentage or in money terms where possible). A relative failure may have had small sales but these would have been completely unsatisfactory in relation to costs.

It was recognised that generalisations relating to one industry might not be valid for others, so that a representative group of innovations would have to be studied in each industry. The two industries selected were chemicals and scientific instruments. The available data relating to industrial innovations did not permit the use of random sampling techniques by industries, and "pairs" were identified and selected largely as a result of literature search, interviews with firms and scientific organisations and previous experience of the team in the two industries. It was recognised that the initial selection of pairs might have some bias, and would not provide a completely satisfactory basis for statistical generalisation. But if the method proved feasible, it was intended to extend the number of pairs for each industry until a secure basis for generalisation were established.

The initial target was to find and complete fifteen pairs (i.e. 30 cases) in each of the chosen sectors. Altogether about 50 pairs were identified, of which 29 were completed.

The main data collection was done by means of a checklist of 120 leading characteristics of an innovation, grouped into areas of interest: the innovation history, the innovating organisation, its R and D department, its environment, the key people involved (the "technical innovator", and the "business innovator" in particular), marketing, production and "hindsight" (what would you do differently now?). A coding system has been devised by which the data may be recorded in various ways according to the type of information. In some cases an absolute quantity is recorded (e.g. cost, firm size, lead time, etc.); in others a relative ranking or a straight 'yes-no'; and in some cases the measures are linked to a classification code (e.g. origin of the innovation idea: (0) inside, (1) university, (2) government defence, (3) government civil, (4) Research Association

(5) related industry, (6) unrelated industry, (7) individuals). The results were processed using the ASCOP programme on the Atlas Computer at the SRC Chilton laboratory. Several uni-variate and multi-variate statistical techniques were used, including principal component analysis, factor analysis, discriminant analysis and composite "index" variables, linking together the single variables relating to a particular hypothesis.

The checklist was not employed as a questionnaire but taken to interviews in order to prompt the memory of respondents. Initially, interviewees were encouraged to talk freely about their own interpretation of the success or failure of the innovation. It is recognised that each case-history is unique and that special factors may be involved which would not be captured simply by a formal questionnaire. A relatively free interview technique has also been found essential in previous case study work in this field. However, the checklist was designed so that the interviewer might ultimately collect all the essential information for analysis of a pair. This would normally require a succession of interviews as well as a technical literature search preceding the interviews. The precise individuals to be interviewed would vary with each case, but would usually include the "chief executive" as well as the "technical innovator", and representatives of the marketing side of the organisation. In addition, interviews would normally be held with individuals outside the firms but closely acquainted with the innovation, such as consultants, customers, and technologists in other laboratories or firms. In this way an endeavour was made to cross-check information, to guard against mythologising processes, and to obtain a complete and many-sided picture of the pattern of events. Typically, three to six interviews would be held for each side of a pair and these would be followed up by correspondence and telephone calls. Whenever necessary interviews were held abroad, and the resultant case collection is international, especially in the chemical industry.

In both the chemical and instrument industries it became clear at an early stage that most of the paired comparisons would have to be international. In particular it was essential that some interviewing could be done in the United States. The project leader was able to visit the United States in 1970 and carry out interviews with the help of the travel grant from the U.S. Department of the Air Force. The results were highly beneficial to the project, enabling the completion of a number of important pairs of case histories in the chemical industry and the initiation of several in the instrument industry. In the

final report of the project it is recorded that of the total of 29 paired cases, 11 were drawn from the United States. Ultimately there were six U.S. success cases and four failures. These figures do not include a number of "halves" which have yet to be completed and which will be taken into the sample when the next analysis is made. Altogether more than twenty companies were interviewed and also a number of other interviews were undertaken at Government agencies in Washington and at universities. The Department of the Air Force grant enabled the SAPPHO Project to gather vital data about innovation in American industry.

An abbreviated version of the SAPPHO Report will be available early in 1972. The results show that, as expected, only a few of the 201 measures which were made for each pair differentiated between success and failure. Most would-be innovators share many characteristics in common, whether they fail or succeed. They almost all conduct organised R and D, form project teams, take out patents, attempt forecasts and encounter bugs in development. Even where they differ, many of these differences show no consistent pattern. For example differences in size, formal management techniques, publications policy, scale of R and D department, rate of growth, and incentives are apparently unrelated to success or failure in innovation.

The clear-cut differences within pairs which do form a consistent pattern related to success and failure may be summarised as follows:

(a) Successful innovators have a much better understanding of user needs. They may acquire this superiority in a variety of different ways. Some may collaborate intimately with potential customers; others may do thorough market research or themselves have the necessary experience of user requirements. But however acquired, this imaginative understanding is the hallmark of success.

(b) Successful innovators pay much greater attention to marketing. Failures were sometimes characterised by neglect of market research, publicity, user education and customer problems.

(c) Successful innovators perform their development work more efficiently than failures, but not necessarily more quickly. They get the bugs out of the product or process before it is launched, not after the user complains. They usually employ a larger development team on the project and spend more money on it. This applies even when the successful firm is smaller than the failure.

(d) Successful innovators make more effective use of outside technology and scientific advice, even though they perform more of the work in-house. They have better contacts with the scientific community in the specific area concerned (not necessarily in general).

(e) The responsible individuals in the successful attempts are usually more senior and have greater authority than their counterparts who fail. In the instrument industry they have more diverse experience including experience abroad. The greater power of the innovators in the successful attempts facilitates the concentration of effort on the scale which is needed and the integration of R & D and marketing.

These results confirm some of the hypotheses on innovation advanced in the previous literature, notably by Carter and Williams in U.K. and by Marquis and Myers in U.S.A. However, they do not support many other explanations which have been suggested.

With the submission and publication (in the near future) of the report, the work on innovation is not considered finished. Indeed, this first phase of the study requires further empirical support in the form of more case histories (so far only one pair has been published because of the confidential nature of so much of the material, but others are being prepared). It is considered desirable to enlarge the data collection in both the existing sectors and to extend it into others e.g. pharmaceuticals, machinery, consumer products, materials (already being pursued for the OECD) and others.