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IMPACT OF THE ENERGY-RELATED INVENTIONS PROGRAM ON THE NATIONAL ECONOMY

by

Marilyn A. Brown
Jonathan A. Morell
Sherri A. Snell
Charles R. Kerley

Oak Ridge National Laboratory[1]

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BACKGROUND AND PURPOSE

It is now well known that technological innovation is a major determinant of productivity growth. New technologies generate jobs, improve productivity, and send spin-off effects rippling through the economy. It is generally accepted that most of the nation's economic growth is due to technological innovation.

Small businesses have been particularly successful in producing creative innovations for the marketplace. Firms with less than 1,000 employees account for more than one-half of all innovations and almost one-half of the major innovations introduced into the U.S. economy. They produce 2.5 times as many innovations per employee as large firms, and they bring their innovations to the market much faster (The Futures Group, 1984; Gellman Research Associates, 1982).

It appears that entrepreneurship is more readily pursued in small business, and it is the personal role of the entrepreneur that frequently makes the difference between mere invention and successful innovation (Roberts, 1969). At the same time, smaller firms tend to face unique barriers to technological innovation. The inventor and potential

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entrepreneur typically have a pressing need for funds to support the activities that will enable the testing, feasibility studies, market analysis, and business plan necessary to gain an adequate assessment in the market place.

This paper discusses the economic impacts of a program designed to provide targeted federal support for non-nuclear energy-related innovation among small businesses and individuals. ERIP is administered jointly by the U.S. Department of Energy (DOE) and the U.S. Department of Commerce/National Bureau of Standards (NBS). The goal of the NBS portion of the program is:

- to evaluate energy-related ideas and inventions, and to select for further support those technically and economically feasible inventions that are likely to increase energy efficiency.

The goal of DOE's efforts is:

- to provide the initial funding for these projects, as well as the guidance necessary to speed inventions toward introduction in the market place.

A secondary goal of DOE is to encourage invention and innovation in the economy as a whole.

By the end of 1986 more than 23,000 inventions had been submitted to NBS, and nearly 400 of these had been recommended to DOE. The evaluation data collected on ERIP participants provide a unique opportunity to learn about the activities of an important group of small businessmen - independent inventors whose background gives them considerable technical expertise, but little experience with commercialization processes. If appropriately nurtured, what kind of economic impact can they have?

This paper begins with a description of the research design. Attention then turns to an analysis of the rates of market entry of the

ERIP technologies and their spin-offs. Levels of sales and employment are then assessed. The paper concludes with a discussion of the total economic impacts of ERIP technologies.

RESEARCH DESIGN

Two sources of data are central to our assessment of ERIP's economic impacts: telephone surveys and personally administered case study interviews with program participants. Supplemental data for the current evaluation are drawn from three other sources: prior evaluation efforts; data collected by NBS as part of their effort to manage the ERIP application review process; and discussions with ERIP Invention Coordinators, the DOE staff contacts assigned to oversee the inventors.

Information was sought for all of the 307 ERIP applicants recommended by NBS to DOE as of June 1985. From this population, information was available for only 204 cases. Some of the inventors were deceased or could not be found, while others declined to be interviewed.

The research design lacks a control group of inventors, making it difficult to determine the ERIP program's specific economic impacts. By comparing the success of participating inventors with statistics from the literature, however, some estimates of impacts are offered.

MARKET ENTRY OF ERIP INVENTIONS

To analyze the progress and impacts of the ERIP inventions, three definitions were developed. Applied inventions are characterized by a direct sale of a unit of product or service, the conclusion of a licensing agreement, the conclusion of a joint venture, or the sale or licensing of a spin-off technology. A more rigorous definition is used to identify the more successful of these inventions. In particular,

commercialized inventions are those with $50,000 or more in sales for any single year from 1980 through 1984, or cumulative royalties of $5,000 over the same period of time. Finally, inventions in the production/marketing stage refer to those in either limited or full production and marketing, and does not include technologies that have been sold only as prototypes.

More than one-third (N=70) of the 204 inventions studied here were applied by 1985; that is, they had direct sales, a licensing agreement, a joint venture, or a spin-off technology with sales or licensing. Eighteen percent (N=37) of the 204 inventions were commercialized (that is, they have achieved a minimum level of sales). Fifteen percent (N=31) of the 204 inventions were in production/marketing.

These findings are quite impressive when compared with the success rates of technological innovations as a whole. One study estimated that it takes some 58 new product efforts within a firm to yield one successful new product (Booz, Allen and Hamilton, 1968). Myers and Sweezy (1976) estimate that only about 10 to 12% of ideas submitted to corporations for screening will enter the development pipeline. Comparisons such as these suggest that ERIP has significantly enhanced the economic prospects of its participants through the endorsement of its NBS screening and by its grants, commercialization education, and other support.

SALES

Gross sales data were collected from ERIP participants for each year from 1980 through 1984. A total of $122M was reported. An additional $99M of gross sales (for a total of $221M) was estimated,

primarily based on assumptions concerning sales through licensees. Extrapolations were then used to estimate sales during 1976-79 and 1985-86, years for which sales data were not collected. The results are shown in Figure 1.

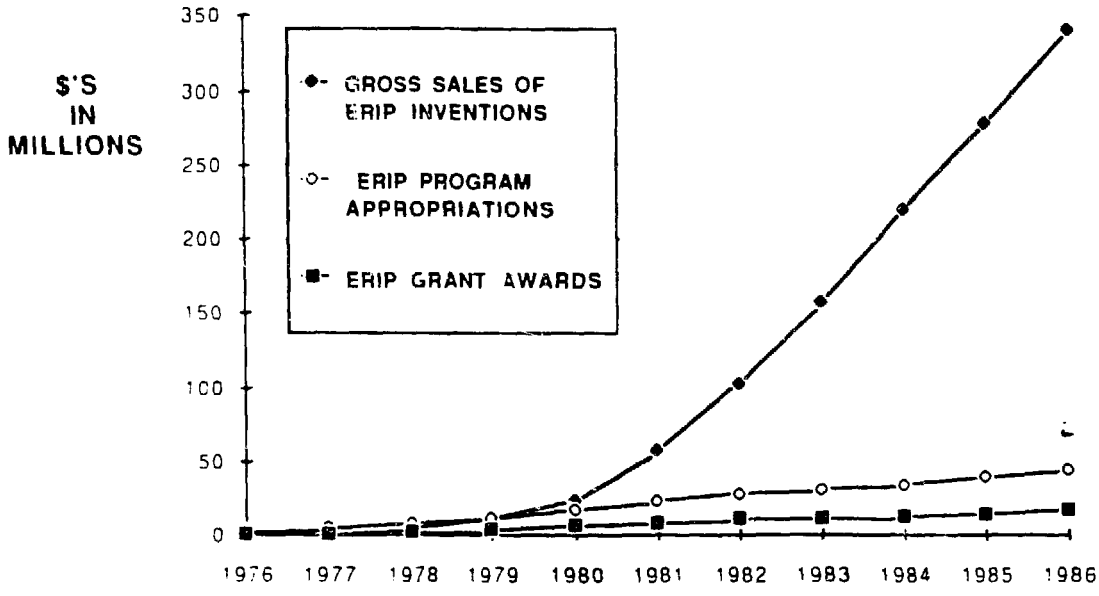

Fig. 1. Cumulative invention sales, program appropriations and grant awards.

Comparing across years, sales grew between 1980 and 1982, and then leveled off between 1983 and 1984. Also shown in Figure 1 are program appropriations and grant awards, on an annual, cumulative basis, vividly illustrating the substantial increase of invention sales over grant expenditures.

Figure 2 shows how the cumulative gross sales of $122M was distributed across the 43 commercialized inventions for which data were available. The range of these sales per invention is quite large. Of particular note are the three inventions for which sales of $10M to

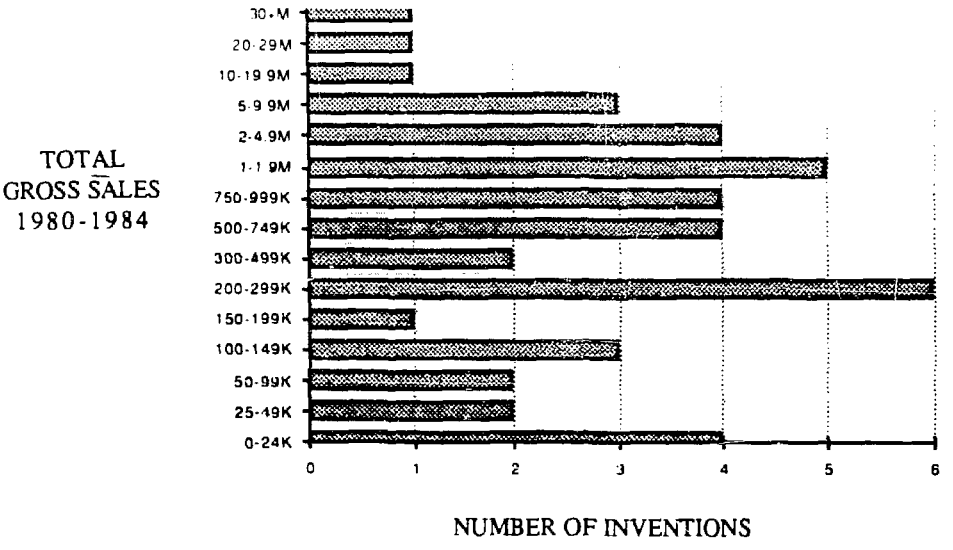

Fig. 2. Distribution of cumulative gross sales for ERIP inventions.

$32M have been generated. These three inventions comprise 61% of the $122M gross sales. They involve the following three technologies:

- o solar space heater;
- o a solar swimming pool cover; and
- o a cooling system for buildings.

The tremendous success of only three of the ERIP inventions is typical of the process of technological innovation. Venture capitalists, for instance, expect that the vast majority of their investments will not pay off, but that the small number of big winners compensate for the large number of failures.

JOBS GENERATED

Interviewees were asked for the number of full- and part-time employees working for them on tasks related to their ERIP inventions. The responses to these questions indicate that the inventors (and their firms) had a total of 619 employees, 371 full-time and 248 part-time, directly working on their ERIP inventions at the time of this

evaluation. Assuming that part-time workers are employed half-time, this equates to 495 full-time equivalents (FTEs).

The 495 FTEs do not include the full- or part-time employment of ERIP inventors. Slightly more than one half of the inventors held jobs at the time of this evaluation that involved specific issues related to their ERIP inventions. Further, the employment reported here relates only to the companies of people who were interviewed in this evaluation. Employment by licensees and entrepreneurs involved in marketing spin-off technologies is not included, except in a few cases where the licensee or entrepreneur was interviewed.

Despite these limitations, our data reveal a significant fact about the relationship between the commercialization of ERIP technologies and job generation: ERIP technologies support more employees than would be anticipated based on national statistics. Consider those 15 inventions for which there were 1984 sales, the commercialization mode was direct sales (as opposed to licensing), and employment data are available. The mean sales per FTE is $78K, and the median is $50K. In contrast, the national average for small businesses with some R&D activity is $107,000 (U.S. General Accounting Office, 1984).

The superior job-generating potential of ERIP technologies may be due to any of several factors, including: (1) low wages and/or low profits due to high levels of personal commitment among ERIP inventors and employees; or (2) high labor intensity of the kinds of technologies supported by ERIP. Whatever the reasoning, our finding is consistent with other evidence that small businesses contribute more to employment growth than large business (Brookings Institution, 1984), and that small

business innovation contributes to higher social rates of return while taking slightly less relative profit (Romeo and Rapoport, 1984).

TOTAL ECONOMIC IMPACTS

The direct employment associated with the marketing of inventions is the most visible employment impact. However, any discussion of the job benefits of marketing inventions is incomplete without noting those industrial sectors that supply intermediate inputs and services to commercialize a new product or process. Commercialization stimulates new demand for energy, materials, equipment, and labor, and generates secondary employment benefits. Simultaneously, decreases in demand occur in sectors that supply inputs to replaced products or processes. The magnitude of the net secondary employment and income impact depends on the nature of the invention, the level of acceptance in the market, and the number of economic sectors affected by the replacement of one product or process for another.

Some of the economic adjustments associated with ERIP products and processes are illustrated in Fig. 3. The series of secondary economic adjustments not only include net energy, materials and labor inputs but also output effects in the form of lower production costs, product price changes, higher wages or profits, and changes in investment and consumer expenditure. As new products or processes gain wider acceptance, subsequent rounds of innovation adoption, resource substitution, and price change in the economy converge on a new equilibrium level of output and employment in the economy. Over the long term, the final outcome can involve new distributions of income and employment among economic sectors, new income distributions across corporations and consumers, and a net effect on U.S. treasury receipts.

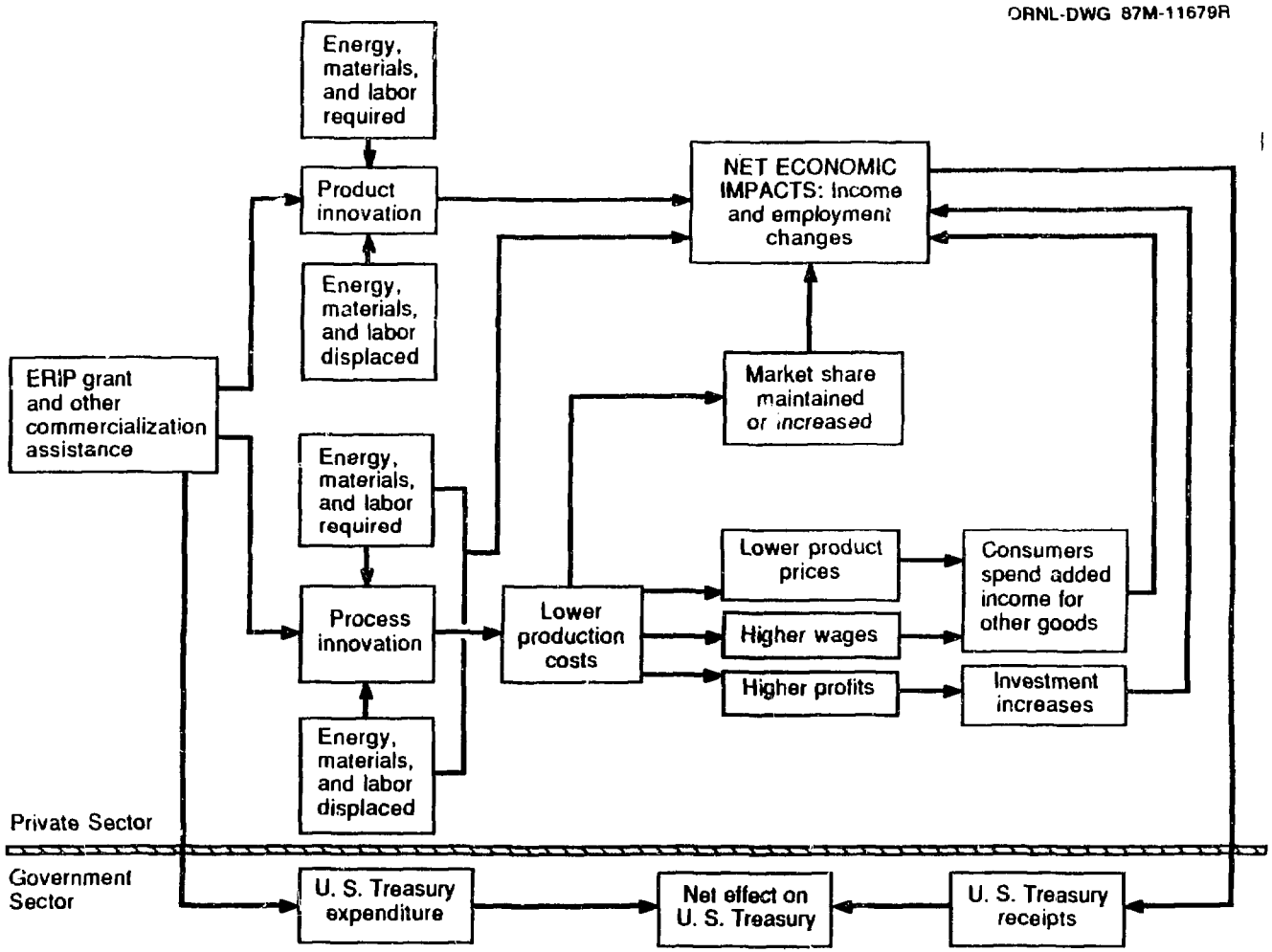

Fig. 3. The economic impact of innovations.

CONCLUSIONS

The market entry, sales, and employment data presented in this paper suggest that ERIP has been able to efficiently produce positive economic impacts. It is likely that the documented successes of ERIP's inventors will be even greater as their projects mature and more current commercialization information is collected.

Survey data presented elsewhere indicate that the ERIP financial support, endorsement, encouragement, and commercialization education are viewed by participants as the most important benefits of the program (Brown, Morell, Snell, Soderstrom, and Friggle, 1987). Other federal, state, and local programs might profit substantially from modelling the composition and delivery of their assistance after the Energy-Related Inventions Program.

REFERENCES

Booz, Allen and Hamilton. 1968. Management of New Products. New York: Booz Allen and Hamilton.

Brookings Institution. 1984. High Technology Employment Growth, 1976-1980: Considerations of Firms Size. Washington, D.C.: U. S. National Science Foundation.

Brown, Marilyn A., Jonathan A. Morell, Sherri Snell, E. Jonathan Soderstrom, and William Friggle. 1987. Evaluation of the Energy-Related Inventions Program: An Empirical Analysis of 204 Inventions. Oak Ridge, Tennessee: Oak Ridge National Laboratory, ORNL/CON-225.

The Futures Group. 1984. Characterization of Innovations Introduced on the U.S. Market in 1982. Washington, D.C.: U.S. Small Business Administration, Office of Advocacy, March, NTIS #PB84 212067.

Gellman Research Associates, Inc. 1982. The Relationship Between Industrial Concentration, Firm Size, and Technological Innovation. Washington, D.C.: U.S. Small Business Administration, Office of Advocacy, May, NTIS #PB82 226119.

Myers, Sumner and Sweezy, E. E. 1976. Why Innovations Falter and Fail: A Study of 200 Cases. (Denver Research Institute, University of Denver), Report R 75-04, NTIS.

Roberts, Edward B. 1969. "Entrepreneurship and Technology," Factors in the Transfer of Technology. William H. Gruber and Donald G. Marquis, eds. Cambridge, Massachusetts: Massachusetts Institute of Technology.

Romeo, Anthony A. and John Rapoport. 1984. Social Versus Private Returns to the Innovations by Small Firms Compared to Large Firms. Washington, D.C.: U.S. Small Business Administration, Office of Advocacy, July, NTIS #PB85 196996.

U.S. General Accounting Office. 1984. Research and Development in Industry: 1982. Washington, D.C.: U.S. Government Accounting Office.

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