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ASSISTANT COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

RELEASED

B-109650

JUL 29 1976

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The Honorable Bob Eckhardt
House of Representatives

Dear Mr. Eckhardt:

In your letter of May 14, 1976, you requested our Office of Program Analysis to "review the information and comment on the statistical validity of the statements made respecting new product activity by small companies" in the study by the Manufacturing Chemists Association of potential economic impacts of the proposed Toxic Substances Control Act.

BACKGROUND

It is generally agreed that the Toxic Substances Control Act would impose costs on firms in the chemical industry, requiring them to perform certain tests and provide data on the results of those tests. The following studies on the implications of the Toxic Substances Control Act have been made public:

1. Draft Economic Impact Assessment for the Proposed Toxic Substances Control Act, S.776, U.S. Environmental Protection Agency, June 1975.

2. Study of the Potential Economic Impacts of the Proposed Toxic Substances Control Act as Illustrated by Senate Bill S.776 (February 20, 1975), Manufacturing Chemists Association, June 1975.

3. Statement on S.776 and the toxic Substances Legislative Issue, Dow Chemical U.S.A., April 1975.

We commented upon those studies in a staff paper and in a letter to Senator Tunney. 1/ Also, Mr. Harry S. Havens, Director, Office of Program Analysis, testified before the Senate Commerce Committee, Subcommittee on the Environment, on October 24, 1975. His testimony was based on the staff paper.

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1/"A Comparison of Three Estimates of Costs of the Proposed Toxic Substances Control Act" (OPA-76-6), Oct. 21, 1975. Letter report to Senator Tunney (B-109650), Dec. 4, 1975, on certain aspects of the Association study.

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In addition to questions about the magnitude of costs imposed by the act, many questions arise regarding the incidence of these costs--that is, who will ultimately bear them? Consumers? Firms? Taxpayers? Workers? To what extent would these costs fall upon relatively small firms? Regarding this last question the Association study offers some evidence, and the purpose of this report is to comment upon the validity of that evidence. Further, we present information from other sources which bears on the question. The detailed results of our review are presented in enclosure I.

Our representatives were informed that you did not wish us to obtain comments or try to obtain additional data from the Association. In our previous work on the Association report, we were told by the Association that survey data would not be disclosed because that would violate agreements made with the surveyed firms.

EVIDENCE IN THE ASSOCIATION STUDY

The study states on page 67:

> "Analysis of 'small companies' shows a higher level of new product activity, per dollar of sales, than the overall sample."

This statement applies to two segments of the chemical industry, inorganic chemicals (Standard Industrial Classification 281) and industrial organics (Standard Industrial Classification 286). The study states further:

> "In the Inorganic chemicals area, new product activity appears to be five to ten times as great among the small companies. In Industrial Organics the activity is 100 times as great."

The study qualifies these statements by pointing out that "these data lack precision because of the small number of companies on which it is based."

The statistical method was to take a sample of small firms, question them about the number of new products they had introduced, and compile the resulting data. From these data, the Association study concludes that small firms introduce new products at a much higher rate (per unit of sales) than the rest of the industry. We believe, however, that this conclusion is not supported by the evidence presented in the study. Even though the nine small firms sampled in the Association study

reported more new products (per unit of sales) than did all of the firms in the sample, this fact alone is not sufficient to support generalizations about the thousands of small firms in the chemical industry. Apart from smallness of the sample, the study fails to provide enough statistical information about its sample to support its conclusion.

RELATED EVIDENCE

The relation between firm size and innovation has been the subject of several economic studies. None of the studies we have reviewed is concerned precisely with the question of new products in the chemical industry. Instead, many deal with research and development spending (rather than new products introduced commercially) and some deal with all U.S. manufacturing (rather than the chemical industry or its components).

These studies do not support the contention made in the Association study that new product activity among small firms is many times greater than in the industry as a whole. Perhaps the nearest that any study comes to such support is a National Science Foundation study (cited in Science Indicators 1974, a report of the National Science Board, National Science Foundation, 1975). Its data indicate that between 1953 and 1973, small manufacturing firms (less than 1,000 employees) introduced about 20 to 25 percent more innovations per dollar of sales than did all firms in its sample. This is much smaller than the difference suggested by the Association study. However, the National Science Foundation study addressed manufacturing as a whole, and may not be indicative of the situation in the chemical industry.

CONCLUSION

On the basis of our review, we conclude that the material presented in the Association study does not support the statements made in the Association report with respect to new product activity by small companies in the chemical industry.

Sincerely yours,

Phillip S. Hughes
Assistant Comptroller General

Enclosure

## REVIEW OF INFORMATION ON NEW PRODUCT ACTIVITIES BY SMALL COMPANIES

According to the Study of the Potential Economic Impacts of the Proposed Toxic Substances Control Act as Illustrated by Senate Bill S.776 (February 20, 1975), Manufacturing Chemists Association, June 1975:

> "Analysis of 'small companies' shows a higher level of new product activity, per dollar of sales, than the overall sample."

This statement applies to two segments of the chemical industry--inorganic chemicals (SIC 281) and industrial organics (SIC 286). The study also states:

> "In the inorganic chemicals area, new product activity appears to be five to ten times as great among the small companies. In Industrial Organics the activity is 100 times as great."

The study qualifies these statements by pointing out that "these data lack precision because of the small number of companies on which it is based."

Any study which tries to generalize about a population (in this case, the smaller firms in the chemical industry) on the basis of a statistical sample must have some means to determine whether the particular sample drawn is typical of the industry or whether it happens by chance to be composed of firms which are not typical. Our comments upon the study fall into two categories--sampling techniques and the interpretation of data. In addition, we present related evidence from other studies.

### SAMPLING TECHNIQUES

At the time of the Association survey, there were approximately 10,000 firms in the chemical industry (SIC 28). The study is based on the responses of 45 of these firms. Because some of these were large firms, the 45 responding firms accounted for about 24 percent of total industry sales. In the subcategories of SIC 28 relevant to the "small firms" question, SIC 281 and SIC 286, responding firms accounted for 15.5 percent and 38.3 percent of sales, respectively.

This degree of industry coverage might be sufficient to give reliable information about the entire industry if appropriate statistical sampling techniques had been used. We found, however, indications of inappropriate statistical

sampling techniques and a failure to present enough information to determine whether other accepted procedures had been follwed.

1. Selection of a sample.

The study does not reveal how many of the 10,000 firms were chosen to receive questionnaires, but it was apparently only a fraction of the 10,000. Given the overrepresentation of large firms, it is clear that the sample was not random. Taking a nonrandom sample of the industry would be appropriate provided that the sampling procedures were carefully designed to assure that the sample was representative of the industry. Otherwise, the inclusion of a few firms that are in some way atypical could lead to a misleading picture of the industry. The Association study reveals neither how large the sample was nor how it was chosen.

The report states that the underrepresentation of small firms means that the survey's bias is to underestimate the rate of new product introduction because small firms are more innovative. But the premise that small firms are more innovative is based on the findings of the survey which, as we argue, may be inaccurate. Thus, the reasoning in that report may be circular. The above statement in the report seems to indicate that no formal measures were taken by the researchers to adjust the results for the nonrandomness of the sample.

2. Response rates.

Apparently, less than 100 percent of the firms sampled responded to the survey. Many reasons for nonresponse may be conjectured. For example, highly innovative firms might perceive it in their interests to respond, while firms that do not innovate might not respond, believing that they would not be affected by the Toxic Substances Control Act. This response pattern would lead to an overestimate of the number of new products. The Association study (p. 56) discounts this source of bias on the grounds that some firms showed no new-product activity and that responses "coaxed" from reluctant companies "shwed no significant profile difference." While these statements are somewhat reassuring to the reader, they are inadequate substitutes for a rigorous treatment of the problem of nonresponse.

The selective "coaxing" creates a problem of bias in itself because it means that firms in the sample were not all treated the same. Perhaps the other firms would have responded differently if they were also contacted personally.

In summary, the Association survey results are based on a sample the size of which is not given, a sample taken by undisclosed (but nonrandom) methods, with an unknown bias because of less-than-full response and the use of different data-gathering techniques for some firms.

INTERPRETATION OF DATA

1. Sample size.

The Association study indicates that there were nine small firms in their sample. Of these nine, it appears that some were in SIC 281 and some in SIC 286. This is a small fraction of the population. In 1972, there were more than 1,000 establishments in SIC 281 and more than 800 in SIC 286.

2. Sample variance.

Sample variance is the other determinant of how representative a sample is. If all firms in the sample were fairly similar, then it would be likely that the industry was homogeneous and that the sample was, therefore, representative. If the sample was diverse--for example, if the number of new products differed widely from firm to firm--then it would be concluded that the industry was heterogeneous in this respect and that a large sample should be taken to lessen the possibility that the sample was atypical.

The study presents no statistics whatever dealing with sample variance. Therefore, there is no way to test the hypothesis that small firms are as innovative as the entire industry.

One clue to the mystery of variation in the sample is the great discrepancy between new substances and grossly modified substances for the sample from SIC 286. According to the data on page 69 of the study, the small firms in the sample introduced publicly no grossly modified substances, whereas for the sample of all firms in SIC 286 grossly modified substances comprised 12 percent of significant developments introduced publicly (page 64). If the data are supposed to be consistent with the hypothesis that small firms are more innovative, then one would expect the small firms to introduce more grossly modified substances than the large firms, because grossly modified substances are also indicative of innovative activity. Since the data show the opposite, it is likely that the small firms in the sample differ greatly among themselves. This, in turn, suggests that the results are probably not statistically significant.

RELATED EVIDENCE

Because of time constraints, we have not attempted to make a thorough study of the relation between firm size and new product introduction in segments of the chemical industry. We do, however, present data which bear upon this question indirectly.

According to Science Indicators 1974 (Report of the National Science Board, National Science Foundation, 1975):

> Large companies (those with 10,000 or more employees) produced a greater number of the sample of innovations between 1953-73 than companies with less than 100 employees, but a smaller number of firms employing less than 1,000; small firms (those with less than 100 employees and those with 100-999 employees) produced more innovations per unit sales than larger firms throughout the period.

This conclusion was drawn from a study commissioned for the National Science Foundation report, which studied the sources of 277 major innovations in U.S. manufacturing between 1953 and 1973. Because this study is concerned with all industry, not just chemicals, and because it defined innovations differently than does the Association report, there is no direct comparability. The data presented are, however, consistent with the hypothesis that major innovations per unit of sales are larger for small firms than for large firms. The difference, though, is far less than what the Association study indicates. According to the National Science Foundation data, small firms (less than 1,000 employees) introduced about 20 to 25 percent more innovations per dollar of sales than did all firms in the sample. This is much smaller than the difference suggested by the Association study, which says that "in Industrial Organics the activity (among small firms) is 100 times as great (as in the industry as a whole)."

Another approach to this problem--which provides ancillary evidence--is to consider the relation between spending on research and development and firm size. According to a 1964 study by Edwin Mansfield, larger chemical firms spent more on research and development (per unit of sales) than small firms. In order to apply this finding to the question addressed in this report, one would have to show a relation between research and development spending and the introduction of new products. There is some evidence on this point, but it applies to all industry rather than to the chemical industry in particular.

Recent research in the economics of innovation shows that many factors affect the rate of innovation besides the size of the firm, such as interfirm differences in technology, product diversification, and availability of funds. Therefore, there may be significant differences in innovative activity among firms of the same size. This suggests that there may be a great deal of variation in the population of firms from which the Association study drew its sample. It also suggests that the costs imposed by the Toxic Substances Control Act would vary from firm to firm and that the size of the firm would not necessarily be a determining factor.