

Issues in Planning for the Transportation Needs of Advanced-Technology Firms

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The Commonwealth of Pennsylvania is actively encouraging the development of advanced-technology industries. Recognizing the importance of transportation infrastructure, the Pennsylvania Department of Transportation has sponsored research at the University of Pittsburgh to understand the relationship between transportation facilities and services and the needs of advanced-technology firms and to determine if current transportation policies and programs adequately address these needs. A brief summary of that research is presented here. Described are the research plan, the results obtained through a telephone survey of advanced-technology and non-advanced-technology firms, and some of the recommendations concerning management of local transportation systems. The primary focus of the paper is the implications of this research—methodological issues that can benefit researchers and substantive issues that can help transportation practitioners. Analysis of the methodology used indicates the need for comparing samples of advanced-technology and non-advanced-technology firms and suggests refinements to the definition of advanced technology. Questions are raised about the transportation needs of advanced-technology firms and government responsibilities for addressing transportation problems.

The Commonwealth of Pennsylvania, in response to the decline of its mature manufacturing industries, is actively encouraging the development of new growth industries. As is the case in many other states, this attention has been focused on “advanced-technology” industries.

Recognizing the importance of transportation infrastructure to the establishment, expansion, and retention of advanced-technology industries, the Pennsylvania Department of Transportation (PennDOT) has sponsored research at the University of Pittsburgh directed at understanding the impact of transportation access and other locational factors on advanced technology firms and evaluating current policies and programs in relation to the transportation needs of these firms. The purpose of this paper is to discuss some of the implications of this research—both methodological issues that can benefit researchers and substantive issues that can help transportation practitioners.

SUMMARY OF RESEARCH

Research Plan

The objectives of the research sponsored by PennDOT at the University of Pittsburgh were to (a) understand the relationship between transportation facilities and services and the needs of advanced-technology firms, (b) determine if Pennsylvania’s current transportation policies and programs adequately address these needs, and (c) make recommendations.

This research project had two phases. The first phase was identification of advanced-technology firms in Pennsylvania. From a short screening survey, firms within five transportation corridors were selected. The corridors were (a) Parkway East, Pittsburgh; (b) Route 202, Philadelphia; (c) Allegheny Valley Expressway, Pittsburgh; (d) State College; and (e) Allentown-Bethlehem-Easton. The purpose of this survey was to gain information about the relative importance of transportation to current business activities of the firms as well as some basic knowledge about the firms. Each firm was described by sector type (i.e., producing a product or providing a service), size defined by the total number of employees, age of technology used in production, and a Standard Industrial Classification (SIC) definition of advanced technology.

The results from this survey were described elsewhere (1). The major finding was that an SIC-based variable contributed little to the prediction of transportation service preferences of the screening survey respondents, whereas such variables as sector type, firm size, and age of technology used in production were important in selecting samples for analysis.

The second phase was an extensive telephone survey of paired samples of advanced technology firms and non-advanced-technology firms in each of the transportation corridors. Comparisons were then made between these two groups of firms to discover if significant statistical differences existed between advanced-technology and non-advanced-technology firms.

The telephone survey identified the unique problems and needs of the advanced-technology firms. Then transportation planning documents from the Pennsylvania Department of Transportation and the local metropolitan planning organizations were analyzed to determine how well these agencies were meeting those needs. Recommendations were offered to help government solve the transportation problems of advanced-technology firms.

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Survey Results

The final report to PennDOT, *Transportation Access and the Location of Advanced Technology Firms in Pennsylvania*, was released in June 1986 (2). The following list is a summary of some of the survey results that are important to planning for the transportation needs of advanced-technology firms. (All reported differences between advanced-technology and non-advanced-technology firms are statistically significant at the 0.01 or 0.05 level, using standard procedures of one-way analysis of variance and homogeneity tests.

- Property reasons, which include availability of a suitable site, location within an industrial park, reasonable cost, prestigious address, and pleasant surroundings, are more important to the location decisions of advanced-technology (AT) than non-advanced-technology (non-AT) firms.
- Transportation facilities and accessibility (such as general accessibility, access to particular areas within the regions, and access to facilities including highways in general, particular Interstates, state highways, and airports) are more important to AT firms than to non-AT firms in their location decisions.
- Highway transport modes are dominant for both AT and non-AT firms, but the mix of modes is different. Express parcel delivery is more important for AT firms and truck is more important for non-AT firms.
- Air transport is more important for AT than for non-AT firms.
- Business travel by air is used to a greater extent by AT firms than by non-AT firms.
- Markets for AT firms are more national and international than for non-AT firms.
- University and college facilities are used more often by AT than by non-AT firms.
- Highway problems are most often cited by both AT and non-AT firms as transportation system concerns.
- Traffic problems are cited more often by AT firms than by non-AT firms.

Recommendations

Two of the recommendations to PennDOT concerned management of the local transportation systems. First, PennDOT should develop more direct mechanisms for improving local traffic management and enforcement. This may require the commitment of new resources to local governments to encourage them to meet basic standards in traffic surveillance, enforcement, and operations. A substantial improvement in the level of traffic signal monitoring and maintenance would go a long way toward meeting many of the local traffic concerns expressed by advanced-technology firms.

Where traffic problems have surpassed the capability of being controlled by relatively low-cost measures, new infrastructure may have to be built. One recommendation being promoted by the commonwealth is public-private partnership to finance specific projects through the cooperation of private developers and the federal, state, and local governments.

WHAT HAS BEEN LEARNED

These results suggest that advanced-technology firms have a different mix of transportation needs and that transportation planning should pay attention to this aspect of economic development. Although the findings presented in the report to PennDOT and summarized in this paper can contribute to "understanding the impact of transportation access and other locational factors to the establishment and growth of advanced-technology firms in Pennsylvania," a more general result of this project can be to help other analysts, as well as transportation practitioners, build on the experience that was gained while conducting this research.

Issues of Research Methodology

Background

At the beginning of the research project, only a few things were believed to be certain. First, a group of industries called high technology, or advanced technology, was emerging as the economic development thrust of the 1980s; and its members might be different from those of the more mature, traditional industries. What actually comprised the advanced-technology group was unclear, although the Commonwealth of Pennsylvania did have a list of SIC codes that was supposed to define the universe of firms.

Second, it was recognized that, to determine if advanced-technology industries were different, advanced-technology firms would have to be compared with non-advanced-technology firms. Surprisingly, few other researchers have made any comparisons between the two groups of firms; their investigations have been limited to such issues as the expansion plans and locational determinants of high-technology industries. They have then compared labor creation rates with the economy as a whole, and locational determinants have often been reported with no frame of reference.

Transportation factors as determinants of location preferences were thought to be of only moderate importance. This introduced the question in the literature of whether high-tech manufacturing firms were "footloose" because they appeared to be less dependent than more traditional manufacturers on access to markets and raw materials for remaining competitive (3).

It was left to the Delaware Valley Regional Planning Commission (DVRPC) to adopt the method of comparing two groups of firms to see if, indeed, there were differences between advanced-technology and other firms in their location criteria and transportation needs (4). The next step would be a research design comparing all characteristics except AT status of advanced-technology firms with those of their non-advanced-technology counterparts.

These considerations led to the two most important initial issues in this research design. They were the definition of what comprises the advanced-technology group of industries and the process to be used for selecting samples of firms for comparison.

What Is Advanced Technology?

The first phase of the research project necessarily required a working definition of advanced technology. After the literature was sampled and no agreement was found on how to define the industries except that, operationally, SIC codes were used, the decision was made to adopt a master list of all of the SIC codes used by other researchers.

For manufacturing firms, this included most of the industries in the following two-digit SIC codes: 28, chemicals; 35, non-electrical machinery; 36, electric and electronic equipment; 37, transportation equipment; and 38, instruments. A few three-digit SIC codes were included (petroleum refining, reclaimed rubber, and ordnance) as was a four-digit SIC code, games and toys.

Service firms included the industries in the SIC codes: 48, communications; 737, computer and data-processing services; 7391, research and development laboratories; 807, medical and dental labs; and 8922, noncommercial research organizations.

Using these SIC codes to define the industries clarifies several facets of a definition of AT. The products or services are considered advanced technology, and the technical nature of the output implies a proportion of technical workers or research and development expenditures, or both, that is above the average. However, because SIC codes are product oriented, they exclude industries whose products are not considered advanced-technology but that use advanced technology processes.

The listing of AT firms in Pennsylvania relied heavily on SIC codes because this identification was readily available. An attempt was made to include firms that used AT processes but did not produce AT products by searching U.S. Securities and Exchange Commission disclosure statements, but these are available only for publicly traded companies and would not include private, probably small, firms that may be experimenting with new processes to produce traditional products. Some of these firms were captured by the third method used to produce the directory, which was self-identification. Searching membership lists of organizations involved with economic development revealed the names of member firms not listed elsewhere that could be added to the AT directory.

The result of this three-step process was the development of a machine readable directory of approximately 4,000 advanced-technology firms in Pennsylvania (5). About three-quarters of the entries in the directory came from published sources that were searched using SIC codes. The other one-quarter was added by using the other two methods.

There was a trade-off inherent in the process used to develop the directory of AT firms. AT firms that might be missed using only SIC codes were included, at the cost of adding firms that would not be defined as AT on closer examination.

The type of firm-based survey research proposed for this project revealed another problem: Many plants are part of a larger company with diverse operations in many locations. A company might be classified by SIC code as AT, but the plant itself should not be included.

The solution must be to decide on a case-by-case basis about including or excluding a firm. For this research project, decisions on some firms could only be made after considering the type of product or service and the age of technology used in

production after this information was gotten by means of a telephone interview. In this type of firm-based survey research, a random sample selected by the computer is not desirable. Because the intention in producing the directory was to be sure to include all AT firms, the error of including firms that might not be AT was allowed. Therefore a judgmental approach is necessary to select the true AT sample. If this approach had not been used, approximately 16 percent of the firms would have been incorrectly classified as AT, a considerable margin of error when using statistical procedures to evaluate differences.

Using Samples for Comparisons

The next issue concerned the way in which the analysis would be conducted. It would not be sufficient to base policy on frequencies of responses by advanced-technology firms with no reference to how non-advanced-technology firms would respond. Instead, comparisons must be made between advanced-technology and non-advanced-technology firms. Relatively simple statistical tests can be used for this type of analysis, providing that the samples are comparable in everything except that which is being analyzed.

The two samples of firms should be similar in sector type, location, and size. In each of the five corridors, equal numbers of AT and non-AT firms were selected. In addition, the AT-non-AT pair in each corridor contained relatively similar proportions of service and manufacturing firms. The two groups of firms were also similar in their overall size distribution.

Although the AT definition in its broadest sense was the criterion for selecting samples, many of the characteristics attributed to AT firms are not readily available to confirm the choices. The telephone survey was designed to provide information that the samples did indeed differ in advanced technology status. Compared with non-advanced-technology firms, the characteristics of the advanced-technology firms follow those that can be described in the literature: employing more salaried employees, using fewer hourly employees, having been established more recently, using newer technology, planning to expand, and even having more employees working on flextime. Therefore it is important to be able to say that samples differ only in the characteristic of interest, AT status, and that results can be truly attributed to differences between the two groups of firms.

In the original experimental design, the proposed analysis was to be by paired difference tests. In the analysis actually performed to determine differences between AT and non-AT firms, pooled difference hypothesis tests were used instead because the strength of the sampling process allowed these simpler testing methods. Statistical procedures available in packaged programs such as SPSS (6) and SAS (7) easily produced the results necessary to fulfill the objectives of the research project. This reinforces the benefit of spending time and attention carefully selecting samples that differed only in AT status.

Further Questions

A few methodological issues remain for future consideration. Preliminary analysis of the screening survey indicated that the

age of technology used in production was an important variable. Unfortunately, this information is not ordinarily used to describe a firm and can only be obtained by contacting the firm. Also, this procedure works much better for manufacturing firms than for service firms. If the process used to produce a product or provide a service is recommended as a factor in defining advanced technology, then work still has to be done to make the choices clear to the respondent.

In this research, the respondent was asked to classify the age of technology used in producing the firm's primary product or service. Choices were less than 1 year, 1 to 5 years, 6 to 10 years, 11 to 20 years, and more than 20 years.

It should be recognized that this was one way to help the respondent understand the question and be able to answer without much hesitation. Other methods may be more easily understood and give more precise information. For example, product and industry life cycles are two perspectives that should be considered (8). The life cycle of a product consists of four phases: (a) the new product is launched commercially and sales rise slowly, (b) sales increase, (c) sales stabilize, and (d) sales decline with the commercial exit of the product. The industry technology cycle consists of three stages: (a) invention, (b) innovation, and (c) standardization. These categories may be adapted to better fit the processes used by the AT firms to produce products or provide services.

A second issue involves the growth potential of these firms. Are the firms of interest advanced technology or are they the firms that will contribute jobs to a local economy? Every AT firm is not a growth firm and every growth firm is not an AT firm.

A third issue is combining service and manufacturing firms in the AT grouping. Service firms have been added to the discussion in only some cases. To many, AT means manufacturing firms. Those researchers who do include service firms generally limit them to communications and computer programming, probably relying on the production of an AT service as the criterion. Ambiguity arises about including firms that use AT processes to provide a non-AT service (e.g., use of state-of-the-art bar coding procedures in grocery stores) and firms that support AT manufacturing as wholesalers of electronic components.

These are a few of the methodological questions raised by the kind of research described here. Discussions will help not only investigators concerned with advanced-technology firms but those engaged in firm-based survey research for economic development as well.

Issues Raised by Results

One objective of this research was to determine the transportation needs of advanced-technology firms. Because so much attention had been given to the problems of defining advanced technology, selecting samples that could be compared, and determining the methodology for statistically testing differences, it was a relatively simple matter to obtain results about the unique way in which advanced-technology firms use transportation facilities and services.

Issues Involving Location Choices

Researchers on this project were careful to specify the unit of analysis for the location question as "within a ten minute driving radius." Results can be compared with those of other studies of locational preferences only after considering how the question was asked. Other studies have used regions within the United States, comparing the seven areas of New England, Midwest, Mideast, South, Southeast, Mountain and Plain States, and Far West or choosing a region within a state.

By asking the respondents why they chose a particular site instead of a nearby site, this research was really asking about what makes a property attractive to a firm. Because this unit of analysis was used, the research was highly influenced by the view that the advanced-technology firms in Pennsylvania did not consider locations in many parts of the United States, but were home-grown—"conceived, born, nurtured, and grown in place" (9).

Given this view that the AT firms in Pennsylvania considered a limited number of options when selecting a site, it was not unexpected that property reasons would be most frequently mentioned by the firms. In this research project, the firms were located in five corridors throughout the state. The two corridors in Pittsburgh were predominantly suburban. One of these corridors was entirely suburban and contained a publicly funded regional industrial park. The other corridor was a mix of firms in suburban locations, a few firms in the central business district, and firms in the university district within the city. In Philadelphia, the corridor was suburban and included a large, privately developed industrial park. The other two corridors consisted of a university town in rural Pennsylvania and an area of three closely related small cities.

What was not part of this research was consideration of the urban firms' reasons for locating at their particular sites. The phrasing of the question using the 10-min driving radius would have given the urban firm the opportunity to consider suburban locations. In the preliminary screening survey, all AT firms in Pennsylvania were contacted by mail and asked why they selected their particular location instead of another location in the area. Of those that responded to that question, 77 were located in center city, Philadelphia. Although this survey was different from the detailed telephone survey that has been reported, it may be useful to mention the results from the location question.

In the screening survey, only one-quarter of the firms mentioned property as a reason for location whereas nearly one-half of the AT firms in the telephone survey mentioned property reasons. Also, 35 percent of the center city firms mentioned business reasons, but only about 16 percent of the AT firms gave such reasons in the telephone survey. Because the surveys are quite different, these results are not meant to be used in a statistical analysis of center city versus suburban firms. However, it does point up the need for research. It is an important research question because different strategies are perhaps needed for urban AT development than for suburban AT development.

In an urban area, proximity to customers may be most important. Therefore, government policies that advocate property development in the center city (the use of abandoned inner-city factories, warehouses, and offices as advanced-technology incubator space) may not be cost-effective. Perhaps

government intervention that might work in the suburbs has to defer to the marketplace in the center city.

On the other hand, a few of these firms did mention that their reason for locating at their sites was the University City Science Center, a downtown research park with close relations with the University of Pennsylvania and Drexel University. When considering urban spaces for AT firms, a link may have to be made to a university. Future research should consider whether the urban space near the university has the proper cost-benefit ratio to justify its development.

Using the area within a 10-min driving radius as the unit of analysis, it was clear that transportation facilities were significantly more important to advanced-technology firms. Also, sensitivity to traffic congestion was found to be significantly more important to AT than to non-AT firms. These conclusions are important because they highlight the need for local governments to pay attention to transportation. Together with the conclusion about the need for appropriate property sites, the conclusions about AT development—at least in Pennsylvania and probably in other states with potential for suburban and small city development—are really directed to implementation by local municipal officials.

Transportation Needs of Firms

Both AT and non-AT firms rely on trucks to deliver their products and private automobiles to get their employees to work. Therefore, in terms of an economic strategy, any projects to improve the road system will benefit a wide constituency.

Both groups also rely on highway-dependent modes to receive their raw materials and supplies. Suppliers ship by truck more often to non-AT firms than to AT firms and by express parcel delivery more often to AT than to non-AT firms; nevertheless, both are highway-dependent modes. Although it was hypothesized that the pattern for suppliers would be the same as that for firms shipping their products and services, this was found not to be true. Nevertheless, it is sufficient to recognize the use of over-the-road transportation modes because any recommendation must include highway improvements.

The most important finding is that a diversified set of transportation modes is used by AT firms to transport their products or services. Use of air service and express parcel delivery is increasing while use of trucks, although important, is decreasing.

Because of the popular notions about advanced technology, air was expected to be an "AT mode" accounting for a high percentage of transport of both products and services. However, only 15 percent of the AT firms did use air, and this type of transport was used for about 8 percent of their products and services, although this use was greater for AT than for non-AT firms. Also, air service was used more often by AT than by non-AT firms for business travel.

It was also expected that at least one of the corridors would be located near an airport. Surprisingly, significant clusters of AT firms were not found around airports; each area did have firms located near its airport, but no well-defined agglomerations were identified. In the AT sample, about 12 percent of the AT firms (19 firms) mentioned proximity to an airport as a factor in making their location decision (for non-AT, the number was 2 firms). Because AT firms are using air for some of

their shipments and about half of their business travel, it appears that a regional airport is sufficient for their needs. Government policy, then, should be concerned with a firm's access to a regional airport rather than its proximity.

Certainly, the question of the use of airports is far from settled. It would be interesting to look at firms at varying distances from an airport to determine if those closer to the airport ship more of their products, receive more of their raw materials, and engage in more business travel by air than firms farther from the airport. Perhaps there is a correlation between air usage and distance from an airport.

Besides air, other modes used by AT firms are truck, company-owned vehicles, mail, and express parcel delivery. The difference between AT and non-AT firms in the use of express parcel delivery of products is worth mentioning. The mode includes overnight letters and parcel service, as well as delivery of packages within several days.

This method of transport appears to be particularly important for the strictly defined advanced-technology firms that produce such products as small electronic components and software. Express parcel delivery may actually be multimodal because, although the product leaves the firm by motor vehicle, it may reach its destination by air. Such linkages may show air transport to be much more important than indicated by the percentage breakdowns of mode use.

Corridor-level analysis of the use of different modes suggested some evidence for this. The AT firms in the Allegheny Valley Expressway corridor, a suburban corridor within about a 45-min drive from the Greater Pittsburgh International Airport, used air for about one-quarter of their transport and express parcel delivery for about 30 percent of their transport. On the other hand, the AT firms in the rural State College corridor used virtually no air transport and used express parcel delivery for about 60 percent of their products and services, although their markets were primarily national and international. The question, then, is how actually different are these corridors. What is not known is how much transport is by air. Perhaps both corridors are really quite similar with their products ultimately reaching their destinations by air but by different connections.

It is possible that any problems of getting to the airport and using air service are being transferred to the private sector that operates delivery services. The firms surveyed offered few complaints about air facilities used to transport their products. It cannot be concluded that there are no problems; private services may be bearing the problems. The new actors, then, to whom government officials may have to listen, are the private providers of express parcel delivery services.

The problems that were most apparent were traffic problems, and the AT firms were more vocal about them. Even highway and bridge problems were not as apparent to the respondents as was traffic congestion. Technically, these problems have good potential for being solved. For relatively modest investments, benefits visible to the general public can be obtained.

The problem appears to be the lack of attention given by local governments to the importance of traffic congestion. It is significant that the governor's commitment to advanced-technology economic development may be undermined at the local level by officials who are not aware of the link between traffic congestion and economic development and the need for responding to the problem if development is expected to continue.

The commonwealth, through the use of state and federal funds, has resources to undertake traffic operations projects. However, when a project is completed, responsibility for maintenance of traffic signals and traffic enforcement is given to local officials who must manage the system. The critical problem appears to be that they do not have the resources to do this. The Pennsylvania Department of Transportation can provide technical assistance and funding to local governments to maintain a high level of traffic operations. An objective of this research project was to make recommendations to the department if current programs were found to not meet the needs of AT firms. Alleviating traffic congestion was the most immediate and direct transportation need that was voiced by the firms, and it can be done within the present government structure.

Another prominent recommendation of the research project was the use of public-private partnerships to build infrastructure when low-cost traffic management programs are not sufficient and new capacity must be provided. Because this is a new focus of Pennsylvania government and the first projects are just being built, this analysis did not uncover any problems with the program. Instead, this appears to be the panacea for replacing federal funding that is being decreased.

Future work is needed to test the assumption that public-private partnerships should be pursued to get projects built. After all, this is just another phase in the history of infrastructure financing. First, the government assumed all financing; then, local governments began paying for preliminary engineering studies to advance projects; and, now, governments are entering into partnerships with private developers or local business firms to raise funds to actually construct the projects.

In California, a state that has a longer history of such funding arrangements, the ethics of private infrastructure financing is being questioned (10). Will the public good be served when the communities with the most money and most aggressive developers have their projects advanced?

In Philadelphia, this process is being used by a large local developer to improve his property and enhance his competitive advantage in the Route 202 "High-Tech" corridor. He has recognized that the problem of traffic congestion may cause him to lose tenants to nearby industrial parks served by roads with fewer and less severe congestion problems. In this case, the needs of both the developer and the AT firms coincide. But who is considering the interests of the small developers and poorer municipalities? This also raises those questions about the two styles of property development demonstrated in Pennsylvania: publicly funded industrial parks in the Pittsburgh area and private development in the Philadelphia area. The discussion about public-private partnerships should also include a discussion about who should be doing the developing in the first place.

END NOTE

In the research report to PennDOT many clear results were presented about the transportation needs of advanced-technology firms in Pennsylvania, and this paper summarized these findings. At the same time, the research has probably raised many other analytical questions, and the purpose of this paper has been to offer some direction for future research on both methodological and substantive issues.

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