Population Forecasting in Small Urban Areas by a Delphi Process

Charles M. Badger, William J. Higgins, and Billy D. Ketron,
Transportation Coordination Division, Virginia Department of Highways and Transportation, Richmond

In the spring of 1974 the Virginia Department of Highways and Transportation initiated the Blacksburg Area Transportation Study. The purpose of this study was to determine the current and future transportation needs of the Blacksburg area. Current socioeconomic and demographic data were collected for the town and for portions of the surrounding Montgomery County. In forecasting the various data parameters to 2000, we encountered complications that involved several special characteristics of the Blacksburg area.

The demographic forecast is a crucial factor in any transportation study and is difficult to develop, especially for small urban areas. In many cases, the rapid growth experienced by a small municipality may be attributed directly to one or two special factors such as an expanding industrial community or the availability of a substantial amount of governmental employment opportunities. A long-range population forecast requires extensive data, which are not always available for small municipalities. Therefore, population-forecasting techniques, such as the economic base method or the cohort survival method, that rely on an extensive data base cannot be used for small municipalities. The town of Blacksburg, Virginia, is an example of this type of municipality.

In 1973 the Virginia Polytechnic Institute and State University (VPI and SU) and other portions of the surrounding Montgomery County were annexed and increased the population of Blacksburg from approximately 11 000 to 24 000. This increase included 8000 students living on campus. When the base-year data were collected for the Blacksburg study in 1974, the population of the town had increased to an estimated 25 520. This increase, along with most of the population growth in the town in recent years, may be attributed primarily to the expansion of VPI and SU. The correlation between the growth of the town and the expansion of the university is shown in Figure 1.

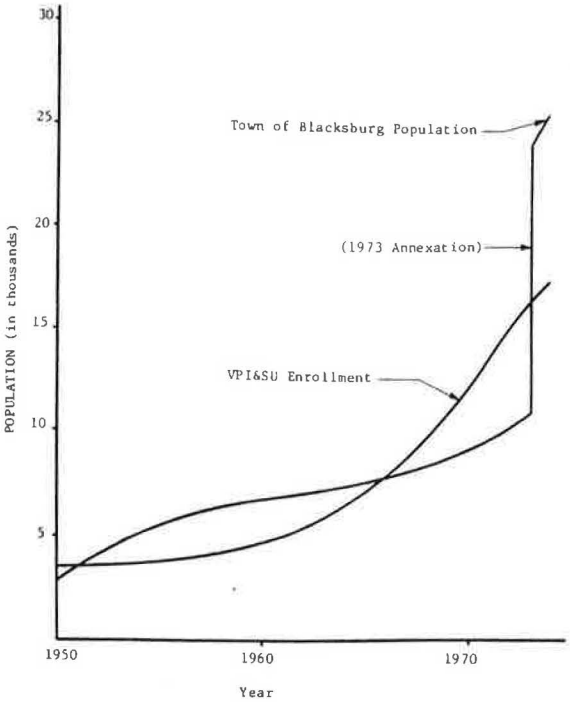
The future of the primary stimulus to population growth in Blacksburg, the expansion of VPI and SU, is known: The Virginia Council of Higher Education has approved a ceiling enrollment of 20 000 students for the university, which is to be reached by 1980. However, the rapid expansion of university enrollment over the past several years has prompted growth in the supporting sector of the economy in the area, which is also developing rapidly but lags behind the in-migration attracted by the university. Therefore, after the university reaches its ceiling enrollment in 1980, there will most likely be a period of time during which the supporting sector of the economy in the area will continue to expand. This expansion will continue until the supporting sector can provide the desired service previously provided by neighboring regional centers. Population growth beyond this point will depend on the expansion in the basic sector of Blacksburg's economy or on the continued growth in the supporting sector or on both. Commercial expansion beyond that required to provide for the needs of the local community may occur if Blacksburg becomes a regional shopping center.

Not only are there economic uncertainties in the area but there is also a lack of historical economic or demographic data available for the town. Therefore, a 2000 population forecast, which was required for the transportation study, had to be based almost entirely on the planner's judgment. If a population forecast based on carefully reasoned judgment is to be developed, then all available information relating to population growth or urban development in the area must be examined. Although there is a lack of historical data for the town, there is an abundance of well-educated, responsible community leaders in the Blacksburg area with a variety of backgrounds and expertise. These community leaders possess knowledge about the area and the trends that affect population growth in the area. Therefore this resource was tapped to develop the population forecast.

A methodology for population forecasting was developed to produce a forecast through a structured interaction among several selected participants. Each participant would be able to contribute his or her

Publication of this paper sponsored by Committee on Urban Activity Systems.

Figure 1. Comparison of Blacksburg and VPI and SU growth rates.



knowledge and insight by responding to the ideas expressed by others. Through this carefully structured process, the group consensus would be determined, and a collective forecast developed. This is the basic premise of the Delphi technique.

DELPHI TECHNIQUE

The Delphi technique was introduced by Helmer and Rescher in 1959 (1). It was originally developed for various applications in national defense planning. Since then, the technique has been adapted to forecasting trends for the business community, formulating goals in metropolitan areas, and developing forecasts for technology. The Delphi technique was adapted during the transportation study to produce a methodology for developing population forecasts.

The Delphi process, as applied to population forecasting, involves the use of structure interactions among a representative group of community leaders regarding the future development trends of the community. The purpose of the process is to reach a group consensus among the participants through a program of individual interrogations that are arranged at intervals and that supply information and opinion feedback (1).

The Delphi process has several advantages over other forms of group discussion that involve face-to-face confrontation. The participants are able to participate in the process at a time convenient to them since the mail-back technique, which is frequently used, does not require the participants to be in one place at one time. All members of the panel participate on an equal basis, and group pressure or pressure by a dominant personality does not occur (2). Since the Delphi process does not employ the committee approach it is more conducive to independent thought and tends to induce the gradual formation of a considered opinion (3).

PANEL OF ADVISORS

The first and most important step in structuring and conducting the Delphi population-forecasting process is to select a panel of advisors. For the Delphi process conducted in Blacksburg, responsible representatives were selected from the government, commercial, industrial, and academic communities in the area and from the local housing and land development industry. Planning officials representing the town of Blacksburg, Montgomery County, the regional Planning District Commission, the Virginia Division of State Planning and Community Affairs, VPI and SU, and the local citizens planning commission were also included on the panel. The Virginia Department of Highways and Transportation conducted the process and therefore was not represented on the 16-member panel of advisors. The essential qualifications sought in the selection of the panel were that the participants should possess enough expertise in their respective fields and have enough knowledge about the area to be able to make responsible and intellectually honest predictions concerning the growth trends in Blacksburg.

Throughout the process, the members of the panel remained anonymous to each other. This anonymity allowed the participants to discuss their opinions in open forum, and their ideas (4), good or bad, could be "judged on their merit and relevance and not by the popularity, authority, or political clout of the author "(4). The participants were encouraged to express their own personal opinions and were requested not to discuss the issues with anyone until the completion of the process.

POPULATION FORECASTING

The Delphi process conducted in Blacksburg consisted of three rounds. The participants were given ample opportunity to express their opinions and to respond to the arguments presented by others. Yet the process did not become too repetitive or lose the interest of the participants. A meeting was held at the completion of the process to allow the members of the panel to discuss the results of the process.

Administrators that use the Delphi process must ensure that the methodology remains flexible. A methodology for conducting the process was developed and presented to the participants before the first round. However, the participants were informed that the methodology could be altered as the rounds progressed and this alteration would depend on the type of response that was received from the panel of advisors. If the response of the panel indicated that the goals set for any of the rounds had not been achieved, an additional round could be conducted or a meeting of the panel could be scheduled before the completion of the process.

Round 1

The round 1 questionnaire was structured to accomplish several objectives. The most important objective was to obtain each participant's ideas concerning the likely impact of various factors on population growth in the Blacksburg area. Another objective was to ensure that the participants produced enough commentary to illustrate the major points of agreement and disagreement on the future of population growth in Blacksburg. Attention could then be concentrated on resolving these issues in subsequent rounds. The questionnaire was also structured to provide the participants with an accurate assessment of the socioeconomic characteristics of Blacksburg in the base year of the study. This information provided a common point of departure from which the participants were to develop a population forecast.

The round 1 questionnaire consisted of three parts. Part 1 provided the participants with a list of factors that to some extent will affect the rate of growth of the Blacksburg area. These factors are as follows:

1. Availability and proximity of future opportunities for industrial employment;
2. Availability and proximity of future opportunities for commercial employment;
3. Availability and proximity of future opportunities for government employment that includes VPI and SU;
4. Availability of labor force;
5. Attractiveness of Blacksburg area versus other localities, based on differential property tax levels;
6. Attractiveness of Blacksburg area versus other localities, based on differential commercial and industrial tax structures and levels;
7. Relative ability of Blacksburg to attract capital for public, commercial, industrial, and individual investment;
8. Attractiveness of local zoning ordinance provisions in Blacksburg, e.g., the superiority or inferiority of the Planned Unit Development ordinance provisions in relation to provisions of other localities;
9. Availability of public facilities, i.e., water and sewer;
10. Adequacy of transportation facilities;
11. Characteristics or quality of the local shcool system;
12. Availability and quality of local medical facilities;
13. Quality characteristics of local medical facilities and services, i.e., fire department, police department, and libraries;
14. Availability and adequacy of shopping facilities for meeting the full range of shopping needs in the community;
15. Availability of residential land;
16. Availability of family recreational facilities, i.e., playgrounds, parks, tennis courts, golfing ranges, and swimming pools;
17. Availability of local entertainment, i.e., social and cultural programs;
18. Attractiveness of climatic conditions;
19. General or unspecified appeal of the town or area;
20. Environmental concerns that arise from the transition of a small town to an urban community, i.e., population density, noise levels, and impact on local air, water, or aesthetic qualities; and
21. Other factors.

The participants were instructed to carefully consider all of the factors and then to rate each factor by assigning it a number so that the total amount of points in the questionnaire would equal 100. The participants were also instructed to assign numerical ratings that reflected the order in which the participants believed the factors should be rated and ranked. In other words, the factors given the most consideration by the panel of advisors should receive the highest numerical ratings and the highest rank. This procedure also applied to those factors that were anticipated to have a negative influence on population growth as well as those factors that were expected to induce growth. The participants were also asked to provide comments that explained the rating of each factor.

Part 2 of the round 1 questionnaire consisted of four additional questions that were included to stimulate thinking among the participants and to provide additional commentary on issues that were anticipated as points of controversy.

Part 3 provided the participants with base-year data on population, employment, housing units, and school enrollment. Each participant was requested to develop a year 2000 population forecast either by forecasting one of the above parameters and then expanding this forecast into a population forecast or by basing his or her forecast on judgment alone after carefully examining the base-year data and considering the reasonableness of the changes in each parameter that were implied by the population forecast.

Round 2

In round 2 of the Delphi process the participants were provided a summary of all the information obtained in round 1 and were requested to complete the round 2 questionnaire. The summary was designed to present the commentary given in round 1 in an orderly, concise, and complete form, representing all the various viewpoints expressed by the panel of advisors. It was also designed to include an assessment of the overall group thinking as expressed in round 1 and to concentrate the attention of the participants on the major points of controversy.

The median population forecast and the range of the forecasts were provided in the summary of round 1 input. Also included in the summary was an assessment of the group's evaluation of which factors were most likely to have the greatest future impact (positive and negative) on population growth in the Blacksburg area. This assessment was determined by examining the order in which each participant ranked the factors and then by calculating the weighted-average ranking for each factor.

A list of statements was provided for each factor. These statements were representative of the various points of view expressed by the participants and were condensations of all the comments expressing similar opinions about the factor. A list of the answers for the four additional questions and supplementary commentary submitted by the panel of advisors were also included in the summary.

The main objective of round 2 was to obtain each participant's response to the opposing viewpoints expressed in round 1. In the round 2 questionnaire, each participant was instructed to rate the factors a second time so that additional commentary would be provided. This second rating was designed to reveal any changes of opinion and to demonstrate which arguments presented in round 1 were considered to be the most convincing.

A population forecast was also requested in round 2. This forecast was to be based on the individual's judgment after the arguments presented in round 1 were considered. The participants were requested to provide a highest reasonable forecast, a lowest reasonable forecast, and the most likely forecast.

Round 3

Round 3, the final round of the process, consisted of a questionnaire and a summary of round 2 input. The objectives in this round were to provide the participants with the results of round 2 and to present arguments, counter arguments, and commentary expressed in round 2.

The summary of round 2 input included the median for the most likely population forecast and a listing of all the forecasts provided in round 2. The form in which the commentary was returned to the participants was altered considerably from that used in the previous round. The comments presented by a participant that concerned one factor were frequently related to a number of other comments that were presented for other

factors, in terms of overall opinion or argument. These comments were listed separately to neutralize the larger arguments. Therefore, the commentary from round 2 was summarized by combining the similar basic viewpoints from all factors into single statements. These statements presented the opinions of the panel of advisors and included only a minimal amount of commentary by the department. The commentary by the department was necessary to effectively combine and edit the comments into a form that conveyed the thrust of the overall arguments.

The completion of the questionnaire in round 3 was optional for all participants. Each participant was requested to consider the overall arguments presented in the summary from round 2 and to examine his population forecast to make sure that it accurately reflected his expectations for the town of Blacksburg. Those participants who wished to change their round 2 forecast or include any additional commentary were encouraged to do so. Those who did not wish to change their forecast or offer additional commentary were not required to return the round 3 questionnaire. The estimates from those participants who did not respond were assumed to remain constant from round 2.

Delphi Process Meeting

Following the completion of round 3 a meeting was held that enabled the participants to discuss the various issues and the results of the process. A brief presentation was given by department Delphi administrators that demonstrated how the questionnaires were developed and the three rounds structured. The results obtained in each round were illustrated, and the final product was discussed. The participants were given a final opportunity to change their forecasts at the close of the meeting.

RESULTS OF THE PROCESS

Round 1

In round 1 of the process, the participants provided population forecasts that ranged from 29 000 to 68 000. The median figure was 42 750. The median figures, rather than mean, were used throughout the process because they reflect central tendency and provide a more accurate assessment of group opinions (4). A brief statistical examination of the round 1 estimates reveals that the mean, mode, and standard deviation figures were 44 566, 50 000, and 11 589 respectively.

The participants provided a wide variety of comments on the factors provided to them and suggested three additional factors for consideration. These factors included (a) the availability of desirable and affordable housing, (b) the upgraded athletic program at VPI and SU, and (c) the characteristics of the populace, i.e., heterogeneous versus homogeneous. The factors ranked highest in round 1 were the availability of future opportunities in government, commercial, and industrial employment and the availability of residential land.

Round 2

The population forecasts provided in round 2 ranged from 35 000 to 58 000. The median for the most likely population forecast increased from 42 750 in round 1 to 45 000 in round 2. This increase was fairly small but it should not be interpreted as an indication that few changes were made in the estimates for round 1. Of the 16 panel members, 10 members made significant changes (1000 or greater) in their round 1 forecasts. (Figure 2 shows the convergence of the population forecasts in the three rounds.) These changes seemed to indicate that the comments and arguments presented in round 1 achieved some degree of success in influencing the judgment of many participants. The mean, mode, and standard deviation were 44 938, 50 000, and 6502 respectively.

The basic arguments presented by the participants in rating and commenting on the factors changed only slightly in round 2. The final ranking of the factors, as determined from the panel's input, was also only slightly different from round 1. However, the rankings in round 1 were more clearly discernible in round 2, i.e., the ranking order of the factors was similar for a greater number of participants. The only significant change in the ranking order of the factors was that labor force availability ranked higher in round 2.

Round 3

In the final round, only two participants chose to alter their forecasts, and this alteration did not change the median figure of 45 000 or the range of 35 000 to 58 000. However, the mean decreased to 44 313, the mode became 45 000, and the standard deviation decreased to 6262 in round 3. None of the participants elected to change their forecasts at the meeting held after the completion of round 3. Therefore, the final 2000 population forecast for the town of Blacksburg that was produced through the Delphi process was 45 000. The median for the lowest reasonable figure that was provided through the process was 35 000, and the median for the highest reasonable figure was 55 000. The Delphi forecast and historic growth for Blacksburg are shown in Figure 3. The anticipated growth rates (i.e., the shapes of the curves) were derived from commentary provided by the panel of advisors.

EVALUATION OF THE PROCESS

The willingness and cooperation of the participants, the convergence of the forecasts in the three rounds, and the acceptability of the population forecast that was produced for the department and the town of Blacksburg all attest to the success of the Delphi process used for population forecasting in Blacksburg. The Delphi forecast of 45 000 fell within the range of reasonable figures for all but three participants (Table 1). Therefore, the product forecast can be considered as an accurate representation of group consensus for the panel of advisors, and this forecast was the main goal of the process.

Conducting the Delphi population-forecasting process in Blacksburg required considerable time and expense. Although a large portion of this time and expense was attributable to research and development, it is obvious that any Delphi process is likely to involve more time and expense than the conventional methods used to forecast populations. Therefore, it is likely that a Delphi population-forecasting process would be cost effective for only special situations in which conventional methodologies are inappropriate.

A population forecast produced by this method has the special characteristic (and advantage) of having been produced by a number of people who are familiar with the area under study and who are knowledgeable in various fields related to urban development and population growth. This characteristic helps ensure the acceptability of the forecast to the planning agencies involved in the study, especially if the agencies are represented on the panel of advisors. A population forecast produced by this method is basically a judgmental forecast, but it is soundly developed because it is based on as much knowledge of the area and of trends affecting

Figure 2. Population forecasts developed by participant using the Delphi process.

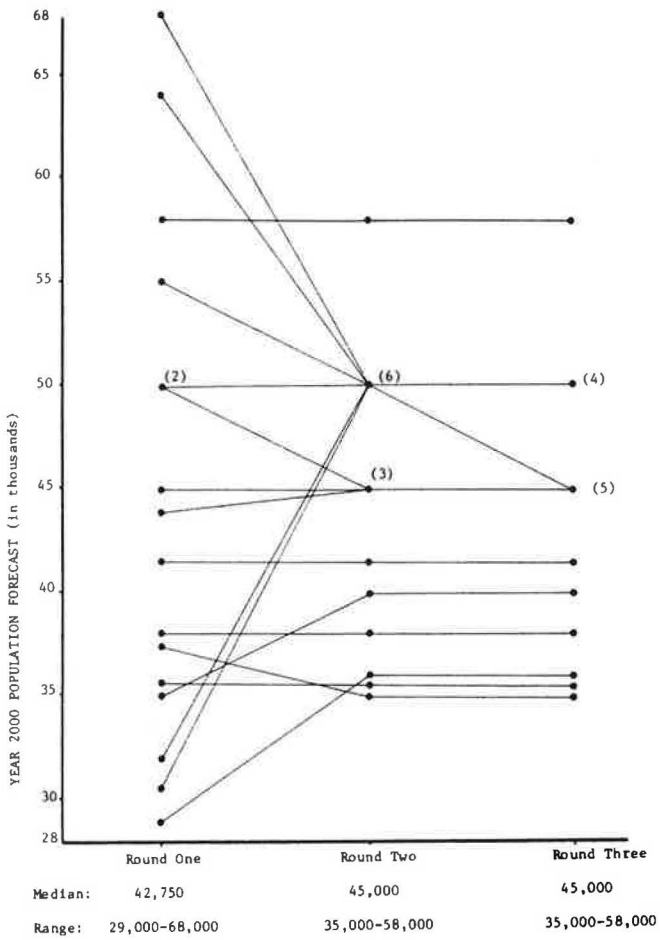


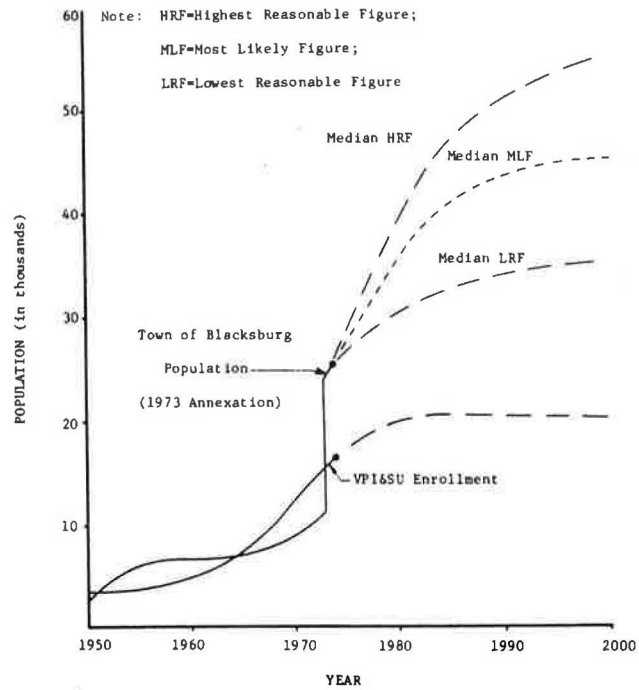
Table 1. Delphi population forecasts listed by ascending order of most likely figures.

	Round 2			Round 3		
Round 1	LRF	MLF	HRF	LRF	MLF	HRF
29 000	25 000	35 000	50 000	25 000	35 000	50 000
30 500	33 000	35 500	41 000	33 000	35 500	41 000
32 000	30 000	36 000	42 000	30 000	36 000	42 000
35 000	32 000	38 000	50 000	32 000	38 000	50 000
35 550	35 000	40 000	45 000	35 000	40 000	45 000
37 500	33 200	41 500	49 800	33 200	41 500	49 800
38 000	35 000	45 000	55 000	35 000	45 000	55 000
41 500	35 000	45 000	55 000	35 000	45 000	55 000
44 000	40 000	45 000	51 000	40 000	45 000	51 000
45 000	30 000	50 000	60 000	40 000	45 000	60 000
50 000	40 000	50 000	55 000	40 000	45 000	55 000
50 000	40 000	50 000	60 000	30 000	50 000	60 000
55 000	40 000	50 000	60 000	30 000	50 000	60 000
58 000	40 000	50 000	60 000	40 000	50 000	55 000
64 000	40 000	50 000	60 000	40 000	50 000	60 000
68 000	50 000	58 000	62 000	50 000	58 000	62 000

Notes: LRF = lowest reasonable figure; MLF = most likely figure; and HRF = highest reasonable figure.
Round 1 median = 42 750; round 2 MLF median = 45 000; and round 3 MLF median = 45 000.

population growth in the areas as is practically obtainable. Therefore, the Delphi process should be considered as a reliable alternative methodology for developing population forecasts.

Figure 3. Growth rates projected by using the Delphi process.



ACKNOWLEDGMENTS

We wish to express our particular thanks to J. David Foster, who is a doctoral candidate in urban and regional planning at the University of North Carolina, Chapel Hill, for suggesting the use of the Delphi technique to forecast the Blacksburg population. Special thanks must also go to Annemarie Riemer, who is an associate at Barton-Aschman Associates. She generously gave of her time and provided us with the insights she gained while coordinating a policy study for the Delphi method in Richmond, Virginia. We also thank Robert G. Corder, who is a state transportation coordinator for the Virginia Department of Highways and Transportation, for his support.

REFERENCES

1. O. Helmer and N. Rescher. On the Epistemology of the Inexact Sciences. Management Science, Vol. 6, No. 1, 1959.
2. P. Leone and Barton-Aschman Associates. The Delphi Technique: A Method for Evaluating the HORIZON 2000 PLAN. Richmond Regional Planning District Commission, Richmond, Va., Sept. 1973, p. 2.
3. N. Dalkey and O. Helmer. An Experimental Application of the Delphi Method to the Use of Experts. Management Science, Vol. 9, No. 3, 1963, p. 459.
4. Delphi: Concept and Application. Barton-Aschman Associates, Washington, D.C., 1974, p. 1.