

Need We Fail in Forecasting?

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Good forecasts are essential to good planning. The past record of forecasting in relation to highway needs has been almost exclusively one of woeful inadequacies, although there are indications that with a longer period of experience on which to build, with more accurate and more detailed statistics, and with better techniques to be applied, the record in recent years has been improving. The purpose of this paper is to examine previous forecasts to determine if they were inadequate, and if so why they were inadequate, and what might be done toward making future forecasts more adequate.

An analysis and evaluation was made of recent (post-war) national projections, especially those made by the U.S. Bureau of Public Roads with the cooperation of the state highway departments, and by certain other recognized authorities in the field of highway economics, from the standpoint of finding answers to two questions: "Did we fail in making our forecasts?" and "Need we fail in forecasting?". A basis of measurement was set up in attempting to answer the first question; those forecasts which essentially meet these requirements over a reasonable period of time were considered to have been successful even though they tended to underestimate the realization to some degree. It was concluded that from the standpoint of the experience record and the pertinent data now available, as well as the improved techniques that can be applied, there is no need for future forecasts relating to the expected demand for highway services to fail to be adequate to a reasonable degree providing there is no major change in the national economy during the period covered. Although the primary emphasis of this analysis and evaluation was on national estimates, some attention was also given to representative state and local projections for purposes of illustration.

Consideration was next given to the basic determinants of highway use and their relationship to the successful forecasting of values related directly to future highway needs. These included total population, potential motor vehicle drivers, gross national product, disposable personal income, density of motor vehicle ownership, and trends in types of vehicles owned. Consideration was also given to factors that affect future highway needs at the state and local levels, such as rural-urban population shifts and local economic trends.

A further study was made of the techniques used and their application in a number of earlier forecasts. Included were considerations of the applicability of straight-

line, growth-curve, and compound-interest type projections. The effects of errors made by forecasters of various factors (such as population) on which future highway demand forecasts must be based, were also considered. Attention was likewise given to the effects of other shortcomings in past forecasting, such as the failure of forecasters to divorce secular and cyclical trends.

It was concluded after analysis that many of the more recently made forecasts have not entirely failed by any means to serve the purposes for which they were made, and that there is no need for future failure in forecasting, particularly at the national level, if the forecasts are made intelligently and with due consideration being given to all essential factors. The needs for interdisciplinary cooperation in making forecasts, and for the frank evaluation of past failures, are stressed. A note of warning of the consequences of failure in future forecasts is sounded.

● **GOOD FORECASTS** are essential to good planning. As never before, the emphasis everywhere is on planning—for next month, next year, the next 20 years, even to the year 2000. But what value is there in making elaborate estimates of what will be needed in the way of housing, schools, hospitals, and highway facilities in 1975 if the predictions of the basic economic factors on which they must be founded, either directly or by implication, are grossly inaccurate?

Planners and prognosticators may take some slight consolation in the realization that their errors have been almost without exception on the conservative side. It is perhaps less expensive in the short range to underestimate needs and to underbuild facilities to meet them; somehow one always manages to "make do" for a while with inadequate facilities. Moreover, the average member of the public, especially when wearing his "taxpayer" hat, is likely to be less critical of underplanning and underbuilding than he is of overplanning and overbuilding, because his immediate out-of-pocket costs are less.

On the other hand, planners, engineers, administrators, and other responsible citizens know perfectly well the tremendous long-range costs of underplanning and underbuilding. They are well aware, for example, of the costs of underestimating future land requirements for public purposes. Thus, land in the outer reaches of larger metropolitan areas, such as the Washington area, that is now sorely needed for schools, hospitals, highways, and parks could have been bought in 1950 for less than \$1,000 per acre, but is now selling for from \$6,000 to \$10,000 per acre—and the prices are still rising.

These statements are not meant to condone and encourage overly optimistic forecasting and planning. They are meant only as a reminder that up to now the ratio of success in attempting to measure and plan for the future physical needs of the economy has not been good, and that it is time to take a critical look at the forecasts which have set the measure of long-range planning, giving careful scrutiny to the mechanics by which these forecasts were made.

The motivating impulse behind this paper came from the business meeting held by the Highway Research Board's Committee on Highway Taxation and Finance on January 5, 1959. A prominent state highway planning engineer raised the following thought-provoking questions:

1. In terms of highway fund revenue, has the end of the postwar growth rate in motor vehicle registrations been reached, justifying the adoption of revised projections?
2. May future growth in gasoline consumption logically be expected to exceed by far the growth rate in adult population?

The committee agreed that study of these matters was warranted. Accordingly, it

passed a motion expressing "its great interest in continuing research and reappraisal of trends in economic and highway revenue forecasting and factors relating thereto." It also charged the committee chairman with "...the encouragement and development of needed research in this area, in cooperation with other committee chairmen in the Department, with the Department, and with other departments." The culmination of these actions came with authorization by the Executive Committee of the Board in June 1959 of the formation of a Committee on Economic Forecasting within the Department of Economics, Finance and Administration.

Of course, these matters had received previous attention by the Highway Research Board. For example, a paper (1) dealing with the evaluation of previous forecasts and one (2) dealing with the improvement of forecasting methods were presented during the 1957 Annual Meeting. Other papers (3, 4, 5) dealing with forecasting in one way or another have been presented at recent Board meetings, and certain project committees have been considering various aspects of related problems.

The purpose of this paper is to examine previous forecasts, with the aim of determining if they were inadequate to serve the purposes for which they were made; if so, why and to what extent; and what might be done toward making better forecasts. Although the authors believe that they can point out some of the grosser shortcomings of past forecasts of economic factors relating to the demand for highway transportation, and that they are in a position to make some suggestions that might aid forecasters, they lay no claim to having developed universally applicable solutions to the major problems that confront all forecasters of economic data. That task is left for the HRB Committee on Economic Forecasting to undertake with the hope that such solutions can be found. Furthermore, the scope of this paper is limited mainly to consideration of state and national forecasts of those economic factors most closely related to the over-all demand for highways: population, total and driving-age; gross national product; personal income; motor vehicle registrations, travel and fuel consumption.

A LOOK AT THE RECORD

The authors seek the answers to three major questions:

1. How badly did we fail in making our forecasts?
2. Why did we fail?
3. Need we fail in making forecasts of the future?

After a look has been had at some of the early and more recent forecasts and they have been compared with what subsequently happened, an attempt will be made to measure the extent of the successes or failures. Then one should be in a position to answer the first two of these questions, and might have a clue to the answer to the third.

Early 20th Century Forecasts

No one with a sense of history would have the temerity to predict with any confidence the exact shape, much less the magnitude of things to come. The dreamers of yesterday of untrammelled imagination—Jules Verne, H. G. Wells, and Edward Bellamy—have turned out to be better prophets than the hardheaded realists of one-half century ago. A prediction in 1909, for example, stated that it was "nothing less than feeble-mindedness to expect anything to come of the horseless carriage movement" in the United States. A proposed 50,000-mile national highway system was attacked three years later as benefitting "a few wealthy pleasure seekers." Trucking simply was not anticipated, and it was stated that "It should be understood... that these highways are intended for... automobile touring traffic, since for long-distance freight transportation it is impossible for haulage over any road surface to compete with the low cost of hauling on a railway." (6)

Woodrow Wilson, as president of Princeton University, said in 1906: "Nothing has spread socialistic feeling in this country more than the automobile," and added that it offered "a picture of the arrogance of wealth" (7). The revolutionary change in the

role of the automobile from a luxury for the few to a necessity for the many has been and continues to be more far-reaching in its results in transforming American life than those peering into the future have been privileged to see. As Owen (8) has warned: "...how inconsiderate history has been of prognosticators who trifle with the future of transportation." He could have added that it has spared neither industrialists, presidents, engineers, nor economists.

Who in the nations's past could have predicted when the canal would have succeeded the turnpike, or the extent and the timing of the development of the railroad? It should not be surprising then, that there was failure to anticipate the full meaning of the automobile. The speeding up of the rate of technological change and scientific advance has now produced a willingness to believe in almost anything. Perhaps a disbelief in change has been supplanted by a too naive credulity in spacemen and interplanetary travel. Whether the new attitude has created a more realistic and precise view of the future remains to be seen.

Pre-World War II Forecasting

The Great Depression jaundiced the economic perspective of most Americans, and all immediately pre-World War II forecasting was hopelessly deluded by the projection of trends of the early 1930's. With the aid of hindsight, it is now known that the growth rate of the motor vehicle was held back drastically by unemployment, loss of income, and the retarded development of suburban home construction. Even so, the industry's propensity to grow was so great that motor travel between 1929 and 1941 had increased by 69 percent in comparison with only 31 percent for constant-dollar gross national product (GNP).*

Nevertheless, some prewar projections, notably that of Charles F. Kettering of General Motors, came very close to the short-range mark. In 1934 he made a high forecast of 34 million vehicles in 1940—almost on the nose. However, his high long-term estimate of 42 million vehicles in 1960 was passed in 1948. Preliminary estimates indicated that 70.4 million motor vehicles were registered by the end of 1959. Yet Kettering's estimate was the highest of the prewar crop of estimates that have come to the authors' attention. His low estimate for 1960, which was apparently viewed by his company as more "realistic," was 37 million, or only a little more than one-half the number of vehicles that will actually have been registered in 1960.

Early Postwar Predictions

The close of World War II found the highway transportation plant of the United States not only grossly inadequate but also sadly depleted. Except for emergency construction there had been no improvements to the highway network since before the war; because of shortages of critical materials and manpower, maintenance levels had been inadequate to prevent deterioration. The rolling stock of the highway transportation plant—primarily the civilian passenger cars, trucks, truck tractors, and buses—was also in a sad state of depletion because with minor exceptions the newest vehicles were at least four years old, and shortages of critical materials had prevented adequate maintenance. Both the government agencies responsible for road building and road mainte-

* It is appropriate here to define gross national product and other economic indicators used in this discussion. These abbreviated definitions are taken from "Statistical Abstracts of the United States, 1959," p. 300: "Gross national product (called GNP) represents the total national output of goods and services at market prices...National income is the aggregate of earnings by labor and property from the current production of goods and services by the nation's economy....Personal income is the current income received by individuals, by unincorporated businesses, and by nonprofit institutions (including pension, trust, and welfare funds) from all sources....Disposable personal income is equal to personal income less taxes on individuals (including income, property, and other taxes not deductible as business expense), and other government revenues (e.g., fines, penalties, etc.) received from individuals as individuals."

nance, and the segments of private industry that could provide the needed vehicles, equipment, and parts faced a herculean task of first meeting the backlogs of accumulated deficiencies and then providing for the growth that was believed certain to occur.

Because even the latest and best of the prewar forecasts of motor vehicles and factors relating to their use were now sadly out of date it became necessary to make new ones, and representatives of government and industry did so, beginning almost as soon as hostilities ceased. In state after state studies designed to determine the physical or "engineering" needs of the highway plant were made; most of these involved forecasts for 20 years or more to cover the period over which it had been deemed desirable for planning purposes that complete adequacy in highway facilities should be attained. One paper (1) in a 1957 symposium on highway needs studies dealt with 34 such studies, of which 22 involved projections of needs (and all related forecasts) of 20 years or more.

Nearly all of these forecasts involved only a single state, however, and although all agreed that a period of accelerated growth in the demand for highways and highway transportation was just beginning, there were not enough of these individual state forecasts available before 1948 to permit the delineation of nationwide projections on that basis. In that year Buckley and Fritts (9) essayed an analysis of the findings of the state highway needs studies undertaken up to that time, and estimated that by 1955 motor vehicle registrations would reach about 46 million, while total motor vehicle travel would reach 450 billion vehicle-miles. However, these forecasts for 1955 were exceeded by the actual registrations and travel in 1950. A graphical presentation included with the paper indicated that by 1970 registrations could be expected to reach about 48 million vehicles and motor vehicle travel about 500 billion vehicle-miles. Both projections appeared reasonable on the basis of the record up to that time.

Methods and Approaches to Forecasting

In 1950 Holmes (10) cited travel forecasts of needs studies made in 10 states since the close of World War II which indicated extremes of only 140 percent to about 270 percent of 1940 travel by 1960. He pointed out that all of these forecasters "employed the method so commonly accepted as to be regarded almost as classic." The steps involved are: (a) Projection of over-all population growth; (b) determination of past trends in density of vehicle ownership, and projection of future trend; (c) combination of values in (a) and (b) to indicate future registrations; (d) determination and application of estimates of average travel per vehicle to arrive at future travel. Such forecasts can then be compared with others independently made (such as other projections of traffic volume) to determine their reasonableness, with final adjustments being made by the forecasters on the basis of their own judgments of the situation. The wide differences in the observed forecasts reflected differing assumptions with respect to the basic elements. It may be stated in passing that this general method is still considered the "classical" method of forecasting such values. Its record of success or failure, and its future applicability, are discussed subsequently.

Holmes also cited another method of forecasting that had recently been tried by the Bureau of Public Roads—a mathematical projection in which the record of 20 years past was used to determine the future trend for an approximately equal period. This procedure, closely paralleling the method often used in estimating the market for new products, resulted in an expected increase in nationwide travel by 1965 to 445 billion vehicle-miles, 65 percent greater than the 1940 total. He pointed out that this forecast agreed very well with the average of the state forecasts cited, but that whereas traffic estimates for 1948 were almost "on the nose" with this projection, those for 1949 and 1950 were already at the levels projected for 1955 and the growth rate was accelerating rather than decelerating, as forecast by the mathematical projections.

He went on to make some pertinent observations concerning the rather close parallelism in trends that had existed from 1920 through 1949 in the growth rates of total motor vehicle travel on all roads and streets and national income on an adjusted (constant) dollar basis. If the somewhat more rapid rise of travel as compared to income prior to 1930 and the differing effects of the 1930-33 depression years were discounted

as reflecting the early "adolescent" growth period of the motor vehicle age, the trends of the two sets of values were found to be nearly identical. He expressed the opinion that a period of "maturity" in automobile travel had been reached, and demonstrated this in terms of vehicle-miles of travel per dollar of national income.

In these demonstrations Holmes brought out relationships between trends in motor vehicle travel and in economic indicators, such as national income, that should have been recognized long before. He pointed out that had traffic trends been thought of in this way there would have been less cause for surprise at what had been generally regarded as the "amazing" growth of traffic in the preceding years. He said also: "Traffic is a part of our economy and grows with it."

Looking toward the future, he made several observations, of which the following are pertinent to this discussion: (a) The United States population was increasing much more rapidly than had previously been considered reasonable, and in a few years the effect of this increase would be noticed on the highways; (b) A rising standard of living, shorter work weeks, paid vacations, and improved retirement and pension plans can be expected to produce added highway travel; and (c) The automobile is remaking the American city, and this, in turn, is resulting in the travel of workers and shoppers becoming increasingly geared to the motor vehicle. On the basis of all the factors considered, Holmes felt justified in predicting "a traffic increase of 4 percent per year (compounded) for a reasonable planning period of 15 to 20 years."

The Holmes paper has been discussed at length here because of the significance of the observations made, which represented, to a large degree, a new approach to the forecasting of motor vehicle registrations and use. However, even his "rash" estimate of future levels of traffic was far too low; 1957 highway travel was nearly 646 billion vehicle-miles (11), or 143 percent of the 452 billion vehicle-miles traveled in 1950, the year the paper was written. He was also probably unduly conservative when he said that a period of "maturity" in automobile travel had been reached, although he certainly did not imply that there would be no further appreciable increases in motor vehicle registrations or travel. The implication of the Holmes paper that perhaps the so-called "classical" methods of forecasting might be basically inadequate is given further consideration subsequently.

Forecasts of the 1950's

As time went on and population, motor vehicle registrations, and motor vehicle travel continued to grow without abatement, various forecasters were encouraged to become much more optimistic than previous forecasters had ever dared to be. Especially noteworthy among the forecasts made during the period 1954-9 were those prepared in response to two directives from the Congress of the United States—the first contained in Section 13 of the Federal-Aid Highway Act of 1954, and the second in Section 210 of the Federal Highway Revenue Act of 1956. Both directives, interpreted in the light of other provisions of the same acts, resulted in compilation by the state highway departments with the assistance of the Bureau of Public Roads of estimates of the physical or engineering needs of all highway systems for periods of from 10 to 30 years. These estimates required forecasts for the same period of the basic indicators of potential highway needs; for example, population, motor vehicle registrations, motor vehicle travel, and motor fuel consumption.

In both instances forecasts for the individual states were submitted by the state highway departments; in most cases they were prepared largely or entirely by highway department personnel, but in some instances the forecasts were prepared elsewhere—usually in other state departments or by colleges or universities. In those states where engineering needs studies had been made recently, the forecasts submitted either were those prepared for the needs studies or were based on them.

Although the Bureau of Public Roads specified the periods for which the forecasts were to be made and provided the states with suggestions on forecasting procedure and other guidelines, the Bureau did not dictate to the state highway departments how their forecasts were to be made. It was believed that state officials were in a much better position to evaluate trends and other pertinent conditions prevailing or likely to prevail

in their own states than was anyone in Washington; besides, it was desired that the physical needs estimates should reflect the best informed opinion of the state engineers, and such estimates would need to be based on forecasts which they could accept.

This does not mean, however, that the Bureau abdicated its review responsibilities in connection with these forecasts. The forecasts for the individual states were reviewed and evaluated in its field division and regional offices before being submitted to the Washington headquarters office, and numerous inconsistencies and other shortcomings were thereby uncovered, brought to the attention of state personnel, and usually rectified before the forecasts were sent forward. A similar procedure was followed by the Washington office, and no forecast was finally accepted until all items questioned had been thoroughly canvassed with the field offices.

In spite of some instances of what appeared to be unduly optimistic or conservative estimates for a few states, both sets of forecasts seemed to be reasonable when summarized by Bureau of the Census divisions or on a nationwide basis. The estimates of vehicle registrations and travel were more optimistic than any that had previously been noted. Nevertheless, they were in line with postwar trends, which gave no indications of abating.

The base year for the forecasts made in the study conducted pursuant to Section 13 of the 1954 Act was 1953; that for those made in the study undertaken pursuant to Section 210 of the 1956 Act was 1956. Approximately the same rates of increase in vehicle registrations were predicted in both projections, but inasmuch as the later forecast started from a base point that was higher than that predicted for that year in the earlier one, the projected values were consistently higher for corresponding years. Another reason for difference was that all publicly owned vehicles were excluded from the earlier forecast, whereas publicly owned vehicles operated in civilian service were included in the later one; inclusion of these vehicles, which totaled about 687,000 in 1953, increases total registrations by about 1.25 percent.

Experience gained since the forecasts for the Nationwide Highway Finance (Section 13) Study were made has indicated that, even with due consideration being given to the numbers of publicly owned vehicles registered, these forecasts have run slightly but not seriously below the subsequent realization. From 1953 through 1960 the average annual registration increase was forecast at 2.03 million vehicles, whereas from 1953 through 1959 the actual average annual increase shown by the registration totals was 2.35 million vehicles. However, the increase of 1955 registrations over 1954, when American automobile manufacturers were making a great drive to increase their relative positions, was 3.2 million vehicles. On the other hand, registrations actually increased by only 1.9 million vehicles in 1957 over 1956, and by only 1.2 million vehicles in 1958 over 1957. Preliminary figures for 1959 indicate an increase of about 2.1 million vehicles over 1958. Putting it another way, the adjusted 1959 forecast of registrations was only about 2.6 percent below the subsequent realization.

Up to the present, the registration projections made for the Highway Cost Allocation (Section 210) Study have run consistently higher than the realizations. Inasmuch as only three years (including the 1958 "recession") are involved, it is still too early to determine whether these forecasts are too optimistic. However, from 1957 to 1960 annual registration increases of 2.5 million vehicles were predicted; the realized average increase from 1957 to 1959 was only 1.65 million vehicles, but the period of time covered is too short to draw firm conclusions. However, the forecast for 1959 was only 2.15 percent greater than the preliminary estimate of actual registrations.

EVALUATING THE RECORD

The nationwide forecasts discussed in the foregoing, and some others, are presented graphically in Figures 1 and 2. Figure 1 compares the actual motor vehicle registrations reported for each year from 1925 through 1959 (the data shown for the latter year being preliminary), with the forecasts made by various selected prognosticators, with some of the projections reaching as far into the future as 1975. It also compares the actual motor vehicle registrations for the same period with a calculated "line of

best fit." This latter relationship is discussed subsequently. Similarly, Figure 2 compares the total miles of travel by motor vehicles as reported by the state highway departments for the years from 1925 through 1958, and the forecasts made by selected prognosticators, again with some of the more recent projections extending as far as 1975.

All of the forecasts shown in Figures 1 and 2 are of the long-term variety in that they attempt to predict what will happen for at least ten years in the future. Those selected for presentation were not necessarily the best or the worst nationwide forecasts available, but they are representative. No examples of short-term forecasts of five years or less were included, mainly because the analyses of the adequacy of

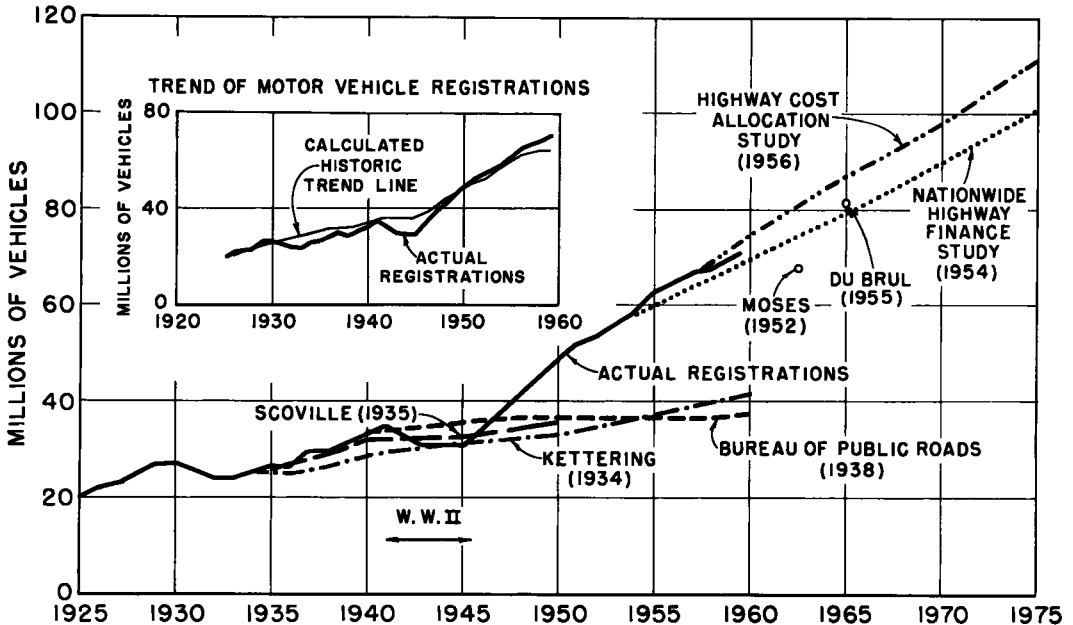


Figure 1. Comparison of United States motor vehicle registration forecasts, 1934-1975, and actual registrations, 1925-1959.

short-term forecasts can be applied as well to the short-term portions of long-range forecasts as to forecasts for only a short period of years. Middle-range forecasts, covering periods of from five to ten years, are relatively uncommon in the estimation of factors relating to the demand for highways, and no need was seen for their special consideration.

Inasmuch as much has been said about the forecasting of trends in factors relating to the determination of highway needs in individual states, this paper would be incomplete without consideration of such forecasts. Accordingly, motor vehicle registration forecasts developed in ten states for statewide highway needs and finance studies, for the "Section 13" study, and for the "Section 210" study, are compared in Figure 3 with the actual registrations reported for the 1940-1959 period (the figures for 1959 being preliminary). The states chosen were selected as being reasonably representative, from the standpoints of rural-urban composition and magnitude of change expected, of those in which statewide needs studies have been made. They also represent the application of a wide variety of forecasting methods and techniques.

Measures of Success or Failure

Before one can determine reasonable measures of the success or failure of forecasts it is necessary to know precisely what it is hoped to obtain from these predictions. Primarily, in this instance, there is sought on a nationwide, statewide, or local basis indications of future demands for highways and highway services that will be accurate enough to permit the development and scheduling of improvement programs, or even individual projects, and the planning of financial schemes that will support them. Other makers or users of forecasts will have interests in other areas, such as the need for educational facilities or the potential demand for a new product or ser-

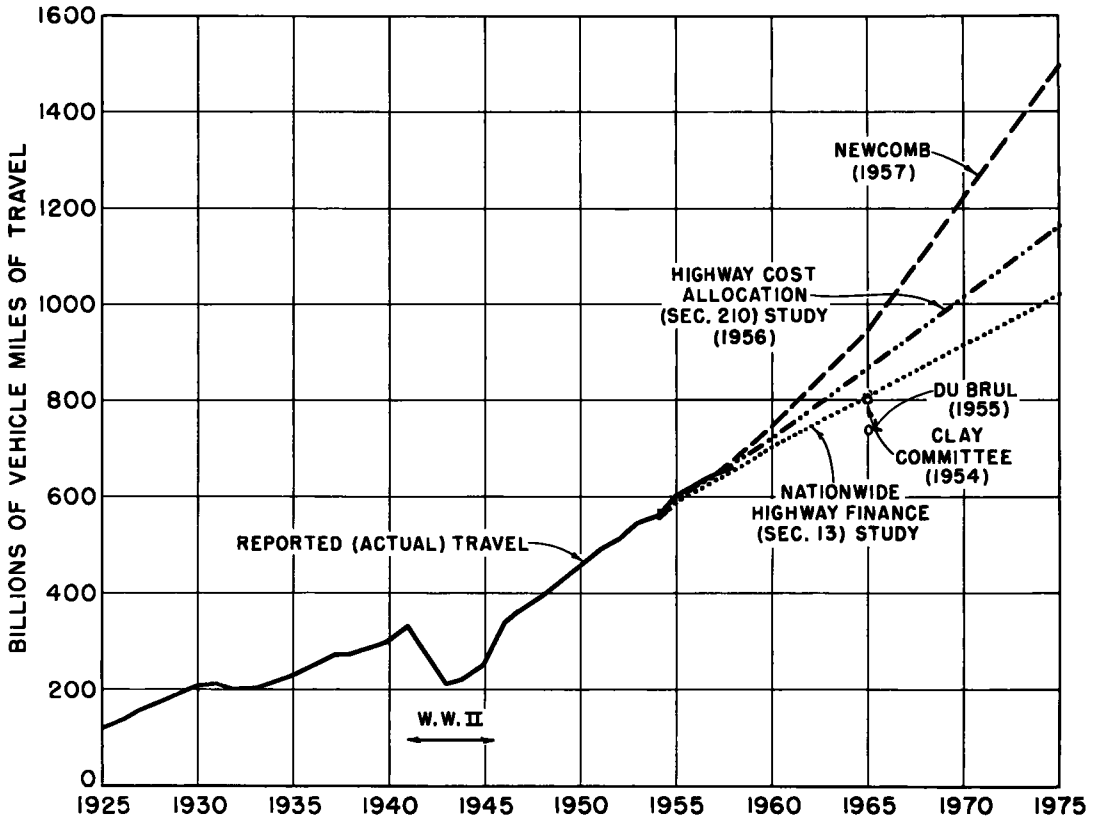


Figure 2. Comparisons of forecasts of total motor vehicle travel in continental United States, 1954-1957, with actual travel, 1925-1958.

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Statewide and nationwide forecasts are used in planning over-all programs, but they are of little help in planning and designing specific facilities, such as a bridge or a section of highway. Neither are they of great help in developing a detailed highway plan for a single metropolitan area or city, regardless of size. For such uses it is necessary to have local forecasts that will predict local conditions in which a great many factors that would not affect even a statewide forecast must be carefully considered.

Examination of a number of past state and local projections reveals the same general story of overly conservative projections of vehicles and traffic. From the statistical standpoint, it is far more difficult to make accurate projections for smaller areas than for the state or the nation as a whole. This is widely misunderstood, and

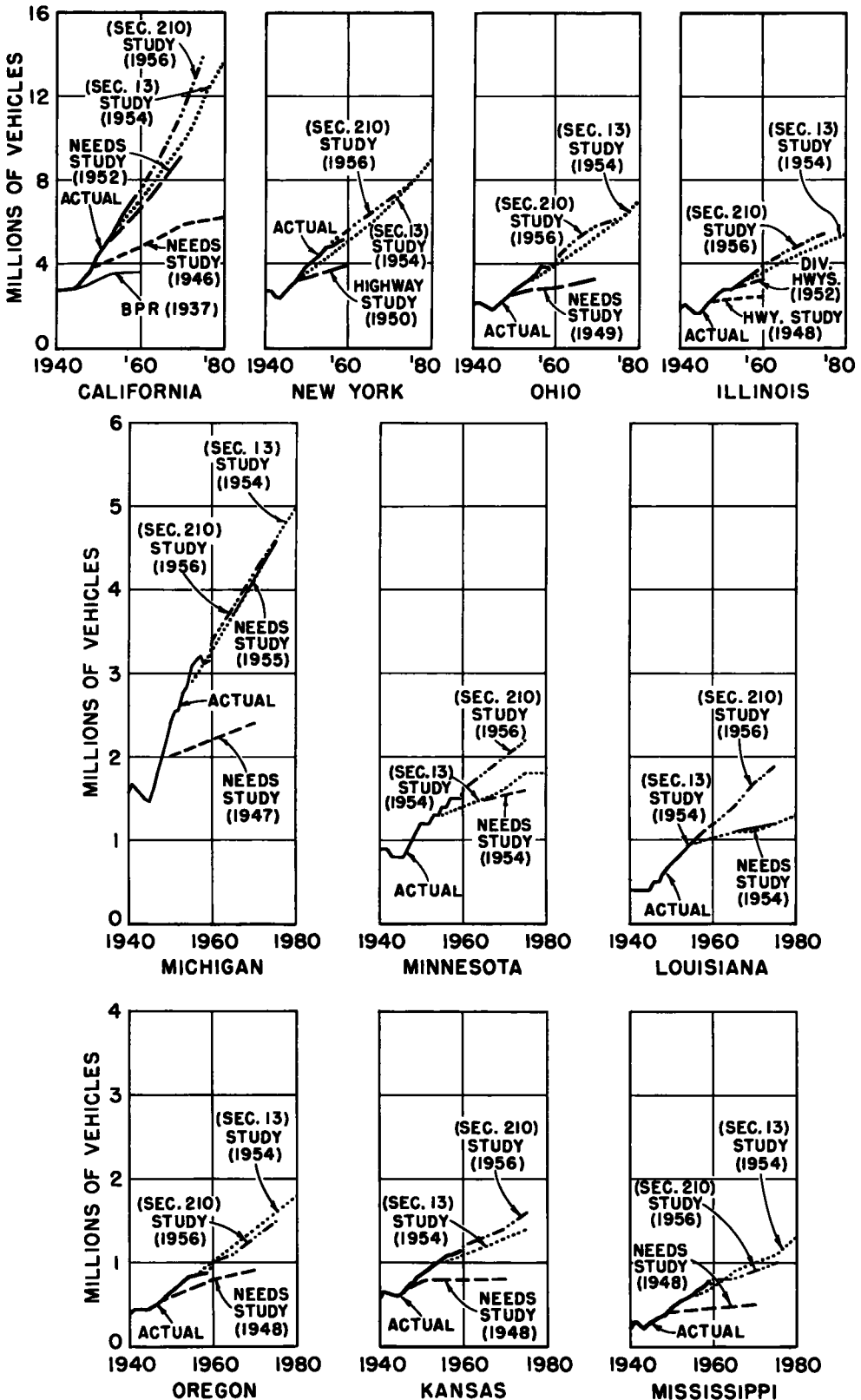


Figure 3. Comparison of state motor vehicle registration forecasts, 1940-1956, and actual registrations, 1940-1959.

it is often argued that familiarity with local conditions may enable the forecaster to be more accurate on a local basis. This notion fails to reckon with greatly increased possibility that single or several events may completely alter the local outlook. Thus in Detroit, for example, the local traffic situation hinges not only on the general national economic situation, but also on the extent to which war or defense orders are placed in the area, the trend in the decentralization of the automobile industry, local immigration, local population trends by type of residence, income, and other factors. When the forecast becomes even more localized, as is the case when dealing with a single facility, other factors such as the travel patterns and desires of local residents, and especially the trends in residential, industrial, and commercial development in the area served by the facility, must also be considered.

The precise objective of a forecast will have an important bearing on the limits of tolerability that are used to measure its success or failure. Thus, a short-range forecast of how many vehicles will be registered in state A next year, a projection of how much income can be expected over the next five years from motor vehicle user imposts in state B, or an estimate of the potential traffic that will use a certain nearly completed bridge the first two years it is opened to traffic should be closely accurate to be of much value. On the other hand, for present planning purposes considerably more leeway can be allowed in nationwide estimates of the motor vehicles to be registered and the travel to be performed in 1980. For one thing, ample opportunity for re-evaluation of the long-range forecast will be available as time goes on, but in the case of the short-range forecasts few such opportunities are possible.

For some purposes a forecast that proves to be on the low side would be acceptable, whereas one that proved to be on the high side would not, and vice versa. Thus, in designing a highway facility it is necessary to have a forecast that will give an accurate indication of the minimum traffic that will use it at the period for which it is expected to provide adequacy. An underestimate here will probably result in construction of an inadequate facility, whereas an overestimate will simply mean that the facility built may be somewhat greater in capacity than is actually required. On the other hand, in planning long-range financing programs it is essential that the predictions relating to revenues not be unduly optimistic, for if they are a sudden and drastic revision of the fiscal program is likely to be required if the long-range physical program is to be kept from bogging down when the income fails to come up to expectations.

Both secular (continuing or long-time) and cyclical (short-time, recurring) trends must be considered in either short- or long-range forecasting, but their relative importance is different in each case. Thus, the importance of cyclical trends can be minimized in making long-range forecasts, while the secular trends become of primary importance. On the other hand, cyclical trends must be carefully considered in making short-range forecasts, although the effects of secular trends cannot be disregarded.

Attempts have been made to set up yardsticks that could be used to measure the success or failure of forecasts of factors relating to the demand for highways. Hansen (1) applied a ratio in which the actual annual rate of change over a selected period of years in the factor being considered was divided by the forecasted average annual rate of change during the same period. He also compared the trends shown in the forecasts under study with the corresponding trends exhibited by the same factors during the 20 years preceding the forecasts, but, presumably, did not set up a mathematical formula for these comparisons.

Hansen studied 33 forecasts made between 1946 and 1954 in 29 states of population, motor vehicle registrations, motor vehicle ownership (density), average travel or highway use of motor fuel per vehicle, and total travel or highway use of motor fuel to the extent that forecasts of these factors were included in the reports. He found some extreme ranges in the ratios of actual rate of change to forecasted rate of change; with a 1.0 ratio indicating that the actual rate of change experienced agreed exactly with that forecasted, he noted ranges of from 0.3 to 6.5 in population, from 1.3 to 14.0 in registrations, from 0.9 to 24.8 in density of vehicle ownership, and from 1.2 to 10.2 in total travel or fuel consumption.

Although it is difficult to make a meaningful concise evaluation of Hansen's rate-of-change comparisons, it can be pointed out that the observed rate of increase exceeded the forecasted rate by more than two times in 16 out of 27 forecasts of population, 21 out of 31 forecasts of registrations, 25 out of 26 forecasts of density of vehicle ownership, and 23 out of 29 forecasts of total travel or fuel consumption. It is an understatement to say, as Hansen does, that "forecasts of travel and related items made during the past decade have been definitely on the low side."

When forecasted trends were compared with corresponding trends during the preceding 20 years, it was found that some forecasters assumed that these trends would not continue. In forecasts of population, registrations, and total travel about one-half of the forecasters predicted that the 20-year trends would be exceeded during the forecast period, whereas the other half expected that the past trends would not be equaled.

A search of available source material has disclosed no generally accepted standards by which the adequacy or success of forecasts can be measured. At the risk of being deemed naive or presumptuous, or both, the authors suggest six "yardsticks" that can be applied to forecasts or projections to gage their acceptability or merit.

Consistency with Past Trends.—A projection or forecast that is inconsistent with past trends is not necessarily wrong, but it is certainly suspect. There may be a sound reason (such as a basic change in the nature of the economy of an area which might be caused by the discovery of a new oil field) why future trends could be expected to differ radically and immediately from those of the recent past, but any indication of such change should be evaluated carefully. The importance of past cyclical trends should be minimized in making long-range projections, but for short-term projections (under 5 years) they cannot be disregarded. For example, cyclical trends can be eliminated in estimating how many automobiles will be registered in 1975, but in estimating the number to be registered next year they must be considered. Several methods are available for smoothing past trends to estimate projections; these include free-hand smoothing, plotting data on similog paper to reduce effects of wide differences, calculation of moving averages, calculation of "least squares" lines, and calculation of other mathematical measures (such as the "line of best fit" shown in the insert, Figure 1).

Comparison of Directions of Forecasted Trends and Realization.—Where it is possible to compare the record of realization with a forecast for an appreciable period it frequently appears that the prognosticator predicted a trend in one direction, whereas the record indicated a trend in another. Hansen, in his analysis of travel forecasts and related predictions, found several indications of this in comparing trends in average travel per motor vehicle or average fuel consumption per vehicle over periods of from 1 to 10 years (1, pp. 105-107 and Tables 1 and 2). The possibility that such differences were caused by cyclical variations should be carefully weighed, but if the difference in direction of trend has continued through more than one cyclical fluctuation the forecast should be carefully re-evaluated and, if necessary, revised.

Comparisons of Rates of Change.—The method of ratio comparisons of actual average with forecasted average rates of change applied by Hansen merits consideration where sufficient experience data have become available between the date of forecasting and the date of re-evaluation. The limits of acceptability to be applied would need to be determined specifically for each case, but for even short periods of time any ratios of actual to forecasted rates of less than 0.5 or more than 2.0 would appear to warrant reconsideration of the forecast unless it were clearly evident that the cause of the difference was largely cyclical.

Percentage Deviations of Forecasted from Actual Values.—One indicator of the adequacy of a forecast is the observed percentage deviations of forecasted values from actual realized values. Here, again, due attention must be given to the probable effects of cyclical trends and the desirability of reflecting them in short-range forecasts. The acceptable limits of error against which the forecasts are to be measured must be determined in each case. Thus, a 5 percent overestimate of statewide travel might be entirely acceptable in a given instance, whereas 5 percent overestimate of state motor fuel tax revenue based on that travel estimate might be

entirely unacceptable because it would seriously overestimate the amount of revenue that would be available to meet existing commitments for maintenance, operation, and debt service.

Comparisons with Economic Indicators.—Highway economists, planners, and administrators are becoming increasingly aware of the relationships that exist between the economy generally and the highway segment. The possibilities of obtaining valuable guidance by comparing trends in factors relating to the demand for highways and highway services with trends in such economic indicators as gross national product, total personal income, and disposable personal income should not be overlooked. The "second differential" factors, such as those that indicate motor vehicle ownership density or average annual rates of travel or fuel consumption, are particularly susceptible of such comparisons. These relationships will be of value in either the making of forecasts or their subsequent evaluation.

The Role of Judgment.—Bassie (12) says: "...the essence of a sound approach to forecasting is common-sense analysis of the important forces making for economic change." He continues: "In this approach, as in any other, judgment is one of the prime requisites. Two others are information and analysis. All three are, of course, interacting." This means that in making successful forecasts judgment must be used in interpreting and applying information; it must also be used in selecting and appraising methods of analysis. Furthermore, it means that it must be used in evaluating forecasts already made, either one's own or someone else's. Application of mathematical yardsticks such as those already mentioned will help toward the evaluation of forecasts; but such yardsticks will not provide exact measures of success or failure.

To appraise a forecast intelligently, the evaluator should have more than a passing knowledge of the basic factors involved; also, he should follow some rather definite rules in making his evaluations. Much of what is required is either stated or implied in what has already been said about the "yardsticks" previously discussed. The evaluator should be fully aware of the intent of the forecast (for example, whether the aim is to estimate short-time fluctuations accurately, or to establish long-term trends from which the realization for any specific year can be expected to deviate) and should appraise it from that standpoint. He should also consider the importance of timing in the forecast; that is, is it essential that the forecasted values be reached at exactly the point in time indicated, or is some "spurt" or "lag" in arriving at these points acceptable.

To be able to evaluate a forecast properly the appraiser should also know the procedures by which it was made; especially whether the forecast was merely an extrapolation of past trends, whether it was the integrated product of several more or less intensive analyses of individual factors, or whether it was evolved by some process intermediate between these two extremes. As Bassie and others point out, a forecast of very poor quality may just happen to predict a situation exactly, but such adds nothing to its fundamental worth or credulity.

It is well, also, if the evaluator is aware of the pertinent traits or biases of the forecaster or of the organization for which he made his forecast. Thus, a forecast made by a prognosticator who is known to be optimistic in his economic views should be analyzed with that characteristic in mind, whereas a prognostication published by an agency known to be extremely conservative in its views should be considered accordingly.

Applying the Yardsticks

Nothing is to be gained by beating a dead horse. Therefore, only passing mention is made of any forecasts made prior to the end of World War II, while the greatest attention is given to those forecasts made since 1950. In the following, various forecasts shown in Figures 1, 2, and 3 are discussed under each of the "yardsticks" previously mentioned.

In considering the graphs and the comments made in the text, it must be remembered that forecasts for each individual year were not available from most of these sources, and that the resulting curves are therefore probably more irregular than the forecast-

ers intended them to be. For example, data for some forecasts were available for only a few "key" years, whereas in other instances the values were estimated from lines plotted to scales which did not permit accurate interpretation of plotted values.

Consistency with Past Trends.—One error that seems to have been made frequently by most forecasters of factors relating to the demand for highways and highway services is a failure to take proper account of past trends. This is particularly evident in the forecasts of motor vehicle registrations made between 1934 and 1938 by Kettering, Scoville, and the Bureau of Public Roads (Fig. 1). Each reflects the short-term, cyclically influenced, trend of the registrations made in the latest year for which data were then available. All seem to exhibit a deliberate disregard of registration trends in the 1920's and appear to reflect the general economic climate of the depression period.

A similar disregard for past trends seems also to be reflected in the 1952 projection of Moses (Fig. 1). It apparently reflects the short-run trends of the time at which it was made, rather than the long-term trends that could have been deduced from the record of the previous 50 years.

The projections made for the Nationwide Highway Finance Study (1954) and the Highway Cost Allocation Study (1956) appear to come much closer to reflecting past long-term trends than do any of the other forecasts shown. It should be noted that both of these prognostications are summations of individual state forecasts, which may or may not be equally consistent with past trends. It should be noted also that the forecast for the Nationwide Highway Finance Study is not entirely comparable with the other forecasts shown because of the exclusion of publicly owned civilian motor vehicles, which consistently account for about 1.25 percent of total registrations.

Thus, of all the nationwide forecasts shown in Figure 1, only the last two mentioned appear to meet the test of being reasonably consistent with past trends. This does not mean that they are necessarily better conceived than the others; it simply means that to the extent past trends are projected into the future these forecasts can be expected to be reasonably close to the subsequent realization.

Only travel forecasts made since 1953 are shown in Figure 2. That of DuBrul, made in 1955, would seem to indicate a departure or at least a slowing down of past trends, and now appears to be unduly pessimistic. That of Newcomb, which appears to be somewhat on the optimistic side, was intended to indicate clearly the "potential traffic that would be generated providing adequate highways were built." (13). The Newcomb curve is of the modified compound-interest type, indicating one constant rate of growth to 1967 and another after 1967. It is rather interesting to note that Newcomb developed two projections of future travel which are directly related to business activity, one indicating what the travel could have been if the highways had remained adequate and the other indicating what the travel still can be if highway investment is increased at a more rapid rate than that which prevailed at the time the article was written.

The composite forecasts prepared for the Section 13 Study (1954) and the Section 210 Study (1956) are both fairly consistent with past trends through 1959, after which they tend to diverge, probably reflecting a consensus that the Section 13 Study forecasts were somewhat too low. It should be noted, however, that the Section 13 study forecast does not include the travel of publicly-owned civilian vehicles, which amounted to about 6.9 billion vehicle-miles in 1954, about 1.2 percent of total motor vehicle travel in that year. The forecast issued by the President's Advisory Committee (commonly referred to as the Clay Committee) was based on the same source material as the Section 13 Study forecast.

It is of interest to observe how the individual state forecasts (Fig. 3) compare with the exhibited trends. For example, the report (14) on the 1947 Michigan highway needs study indicates a direct break with past trends because forecasts "which have proved remarkably accurate in the past show that registration will increase steadily in future years but at a gradually decreasing rate." This forecast was carefully prepared, following the "classical" approach; but it proved to be far too conservative, as the registration record of the next ten years clearly indicates.

This development was taken into account when the forecasts were made for the 1955

study of Michigan's highway needs (15), which noted that, "in restudying the trend of future travel for this report, maximum use has been made of population forecasts by the U.S. Bureau of the Census and of studies of motor vehicle registration and traffic growth by the Planning and Traffic Division of the State Highway Department." It was stated further that the registration forecasts were "based on registration-density increases to about 2.3 persons per vehicle in 1965 and about 2.1 persons per vehicle in 1976." The resulting projection was approximately a straight-line increase to 1980.

This registration forecast, that made for the Section 13 Study (1954), and that made for the Section 210 Study (1956), all match very closely, and all reach the same point in 1976. Through 1957 the registrations showed a tendency to outstrip all the forecasts, but the 1958 recession, which hit the Michigan-centered automobile industry especially hard, caused an abrupt apparent reversal of trend which is undoubtedly only temporary.

Unduly conservative interpretations of trends are evident in the earlier (pre-1951) forecasts for other states, notably California, Illinois, New York, and Ohio (Fig. 3). In these four states the later forecasts appear to be much more nearly "on the beam" in interpreting past trends.

In closing this discussion it seems pertinent to observe that in interpreting past trends forecasters in general appear to be too prone to give full weight to current cyclical fluctuations, especially if these are on the conservative side. Perhaps not enough attention has been given in the past to the application of smoothing techniques, which might have been helpful in trend interpretation.

Comparison of Directions of Forecasted Trends and Realization.—In discussing the consistency of the forecasts shown in Figures 1, 2, and 3 with preforecast trends some comparisons were made of the forecasts with the subsequent realizations. Except for what appear to be short cyclical fluctuations, no complete reversals of trend are exhibited. As previously mentioned, however, there are several instances where the observed differences in trend between the projection and the realization are so pronounced as to throw great suspicion on the forecasted values. In short-range forecasting such an indication for even a single year is sufficient to discredit the forecast, but in long-range prognostication such divergences usually become serious only if they continue for three years or more. Review of historical registration information indicates that major fluctuations, such as those caused by depression or war, may require as long as five or six years to be completed.

It is obvious that the depressed situation in Michigan that was first reflected in registrations for 1958 has temporarily, at least, brought all registration forecasts for that state into serious question. However, if 1960 brings strong economic recovery the actual registrations may closely approach the projection of the 1955 needs study. Similarly, the trend in New York registrations from 1957 through 1959 makes the Section 210 Study forecast appear too optimistic, and the Section 13 Study projection appear very acceptable. However, a good sale of 1960 model automobiles in the state could quickly reverse the picture.

Comparison of Rates of Change.—Calculation of the relationship of nationwide actual to forecasted rates of change in registrations, as projected in 1954 for the Nationwide Highway Finance Study, yields a ratio of 1.27, a rather favorable relationship when viewed in the light of Hansen's findings. The forecast made in 1957 for the Highway Cost Allocation Study is still too new to permit a meaningful comparison of rates of change. However, for the three-year period involved the ratio is 0.65. When similar calculations are made for the travel data shown in Figure 2 it is found that the ratios for these two projections are even closer to unity, the perfect condition.

All of the earlier studies of the states shown in Figure 3 were among those for which ratios were calculated by Hansen (1). Without exception, the experience since 1955, the last year covered by Hansen's analyses, has borne out his findings with respect to these projections. It will now be of interest to see what similar analyses of later projections for some of these same states will show.

Over a period of 12 years (1948-1959) the actual rate of increase in Kansas registrations was 3.6 times as great as that forecast in the 1948 needs study. From 1955 through 1959 the rate of increase of registrations was 1.5 times the rate predicted in

1954 for the Nationwide Highway Finance Study. From 1956 through 1959 the rate of increase of registrations was about 0.8 of the rate predicted for the Highway Cost Allocation Study. It is obvious that on a long-term basis the 1948 needs study projection was far too low, whereas preliminary indications are that the 1954 projection was a bit on the low side although the experience period is still too short to reach a definite conclusion.

Predictions made of future registrations in Oregon illustrate some rather unusual results. The State's economy and population expanded rapidly during the World War II years, but the rate of growth has slowed appreciably in recent years. From 1947 through 1959 actual registrations rose one-third faster than the 1948 needs study indicated. However, from 1954 through 1959 registrations increased approximately one-half as rapidly as was predicted for the Highway Finance and Highway Cost Allocation Studies.

The 1959 preliminary registration estimate for the state shows a total of 874,000 vehicles, up 29,000 and 3.5 percent over 1958. Assuming that 1960 registrations show a similar rate of increase, the number of vehicles registered will be only slightly lower than the 1970 needs study forecast. Although the forecasts used in the Highway Finance and Highway Cost Allocation Studies are somewhat higher than actual registrations, the elapsed time since the studies were made is too short for a secular trend to be established.

A reasonable recovery of the state's economic growth could well bring registrations up to either of the two later forecasts.

Percentage Deviations of Forecasted from Actual Values.—The Nationwide Highway Finance (Section 13) Study forecast underestimated actual nationwide registrations in 1959 (Fig. 1) by about 2.7 percent, while the Highway Cost Allocation Study forecast overestimated them by about 2.4 percent. Although errors of such magnitude are within the limits of acceptability for some purposes, they would not be acceptable for others.

The comparable nationwide travel estimates shown in Figure 2 are proportionally much closer to the totals reported by the states, however. The actual travel reported for 1958 was about 0.75 percent higher than the Section 13 Study estimate, and about 1.5 percent under the Section 210 Study projection. In evaluating these relationships it should be remembered that the so-called "actual" travel figures are computed in such a fashion that their accuracy cannot be pinpointed within the range of the two forecasts. Therefore, for purposes of total travel prediction it may be assumed that so far both forecasts are "right on the nose."

Comparisons with Economic Indicators.—Comparisons of trends in economic factors, such as gross national product (GNP), and indicators of the demand for highways at the national level are discussed subsequently. Some of the national economic indicators best-fitted for such comparisons—gross national product and national income, for example—are not available at the state level, so other, perhaps less desirable, indicators must be used.

Economic indicators have by no means been disregarded by highway planners and economists at the state level in making estimates of the future need for highways and highway services. The so-called "classical" method of projecting future motor vehicle registrations and travel, or some variation thereof, was probably included in each of the state needs study forecasts shown in Figure 3. This method involves comparisons of population trends with motor vehicle registrations, both in total and on a density (for example, persons per vehicle) basis.

In the report on the 1948 study in Illinois an entire chapter (16, pp. 52-58) was devoted to the "future development of the state in relation to highways," in which consideration was given to various aspects of the state's economy, such as the growth of industry, trade, and agriculture; the effect of recreation on highway travel; and the dependence of other forms of transportation on highway travel. Trends in total population and its rural-urban composition were also considered. However, only the population trends and projections seem to have been taken into account in making the registration projections (16, pp. 188-190). Future travel was predicted on the basis of estimated population increases, motor vehicle registrations, and gasoline consumption (16, p. 57).

Similar attention has been paid to economic factors other than population in numerous other instances, such as the California needs and finance studies (17, pp. 58-66; 18, pp. 6-9; 19, pp. 47-54). Zettel (19), in his 1952 highway financing study, gave careful consideration to comparisons of California data and estimates with the United States totals in such areas as population trends, population per vehicle, and gallons of motor fuel consumed per vehicle in projecting his estimates for the future. His forecasts, although somewhat conservative, have proved reasonably accurate.

The record would indicate that although nearly all highway planners and economists have recognized the relationships that exist between certain basic economic indicators and measures of highway demands, they have generally failed to consider all such factors that are pertinent to their analyses, and to give adequate weight to those they did consider, in making their forecasts. However, the excellent records made by a few forecasters, such as Zettel, whose projections have proven unusually accurate, would appear to point up the great possibilities of such an approach.

The Role of Judgment.—There is a humorous adage that says: "When all else fails, try common sense." Nowhere does this maxim seem more applicable than in the making or evaluating of forecasts.

In evaluating the forecasts presented in Figures 1, 2, and 3, the application of judgment is necessary in measuring the acceptability of any of them according to the yardsticks already mentioned. For one thing, the principal intent of all of them seems to be to predict general nationwide or statewide future levels on a long-range basis. Therefore, a wider latitude in the predictions is more permissible than would be acceptable under other circumstances. Similarly, the timing of these long-range forecasts can be considered somewhat elastically; it is probably sufficient for current purposes in 1960 to know that sometime between 1962 and 1965 nationwide motor vehicle registrations can be expected to reach 80 million vehicles, and that they will probably continue to increase at a rate that will bring the total registrations to 100 million vehicles sometime between 1971 and 1974.

The general procedures followed in making most of the forecasts shown in Figures 1, 2, and 3 can be deduced from published reports or other documents; in fact, it can be determined that the so-called classical procedures were followed in part or in whole in all of the more recent ones. In many instances the philosophy of the forecasters themselves, or of the organizations involved, is known to be on the conservative side; for example, they are not likely to be unduly optimistic in interpreting past or present trends. Inasmuch as most of the prognosticators are engineers or are affiliated with engineering organizations, this is not unexpected.

Common-sense judgment, tempered by the information available and knowledge of the analysis methods used, can be applied in connection with the other yardsticks mentioned to interpret any of the forecasts shown in Figures 1, 2, and 3 as of today. However, such judgments must be re-evaluated periodically or they will lose their applicability.

Some Questions Answered

It is now possible to give tentative answers to two of the three questions raised at the beginning of this section, and to suggest the possibility of an answer to the third.

There is no question but that forecasters of the demand for highways and highway services have failed badly to predict what was actually going to happen, even up to the relatively recent past of 10 to 15 years ago. There seems to be reason to believe, however, that the more carefully conceived long-range forecasts made since 1950 of future motor vehicle registrations and travel may not be too badly out of line, if the examples cited herein can be taken as being reasonably representative.

One reason why the early forecasters, especially those who made their forecasts prior to World War II, seem to have failed so badly in their predictions is that they were making their forecasts at the very early-adolescence period in the growth curve of motor vehicle registrations and use. Their problem was made more complex by the absence of adequate projections of other indicators, such as population, and by the cyclical effects of the Great Depression, which were not completely overcome before the "war boom" started just prior to the entry of the United States into World War II.

These conditions provide a partial but not a complete answer to the second question: "Why did we fail in making our forecasts?" A further answer must be sought in the techniques and judgment employed in making the forecasts. During this period great strides in improving forecasting techniques were being made in other areas, such as that of demography, and these techniques began to be adopted by forecasters in the highway field. Sometimes the new techniques were applied improperly or without sufficient background to justify their application. This is particularly true in the case of the application of mathematical formulas to forecasting. The inset in Figure 1 clearly illustrates this point. The solid line shows actual registrations from 1925 through 1959 and the dashed line shows the location of a mathematically computed historic trend line of "best fit." It is obvious that if the upsurge after 1955 is anything but a cyclical fluctuation the calculated line is going to be sadly deficient beyond that point.

It can be assumed that the more competent early forecasters employed the best possible judgment in making their forecasts. However, judgment must reflect experience and in the areas in which they were attempting to make their projections, experience was sadly lacking.

It would seem then that here is the kernel of an answer to the third question: "Need we fail in making forecasts in the future?" The experience to date with the nationwide forecasts made for the Section 13 Study and more recently for the Section 210 Study, coupled with the experience of recent studies made in individual states (such as those shown in Figure 3), would indicate that both the techniques and the know-how are at hand for making better forecasts in the future provided intelligent use is made of the available information and techniques, and provided further that certain basic assumptions or factors are not changed significantly during the period for which the forecasts are to be made. To provide a more complete and accurate answer to this question attention is now turned to consideration of the basic determinants of highway use and their relationship to successful forecasting, and to the possible improvement of present forecasting techniques and their application.

BASIC DETERMINANTS OF THE DEMAND FOR HIGHWAYS

For five decades now, the rate of growth in motor vehicle use has exceeded the growth rate of the population, the economy in terms of goods and services produced (GNP), and of spendable income (DPI). What are the factors that have made this so? Why has automotive travel far exceeded the most optimistic (or pessimistic, depending on one's point of view) levels envisioned either before or immediately after World War II? Will these trends continue? Can any better prognosticating in the future be expected with any real confidence?

Without good forecasts there can be no good planning, and it has become increasingly important that planning be geared today to the "exploding" metropolis, where almost all of the recent national growth is concentrated. Moreover, the rate of growth of vehicular registration and travel since 1950 has been even more rapid than that since 1929 and, apart from the temporary hesitation of the business cycle, shows no tendency to decelerate.

Both the private automobile and truck segments of the motor vehicle industry in the United States have remained growth industries. Automobile purchases reflect the expenditure of an increasing proportion of consumer income for private transportation, the growth of two-car families, the movement toward the suburbs where passenger automobile ownership is most necessary, and the rise of incomes in the lower and middle ranges. For predictive purposes, all of these factors must be evaluated. They are evidenced in the steady increase in the density of motor vehicle ownership. The growing popularity of the compact car must also be reckoned with as a factor which might possibly affect the existing trends in registrations and travel. The share of intercity freight hauled by truck has doubled in a little more than the past decade.

Not to be overlooked or minimized is the traffic-generating potential of a completed Interstate Highway System and its effect on individual travel habits and total travel.

Nevertheless, in the long run these factors are not expected to continue indefinitely

without slackening. Acceptance of this as a fact has colored past appraisals of the future, impelling practically all forecasters to pull the rate of growth downward, generally within a few years of the time the forecast was made to be on the low or "safe" side. Further study of these factors, and of the factors behind them, is in order.

Population Trends and Highway Forecasting

Astute forecasters of the demand for highways and highway services have long recognized the close tie-in between people and motor vehicles; the more people, the greater the demand for automobiles, trucks, and buses and the services they can provide. Therefore, in making their predictions the better-informed highway economists and planners at national, state, and local levels took account of past trends and future estimates of total population, its changing rural-urban and age compositions, the density ratios of motor vehicle ownership to population, and so on.

Believing in taking advantage of the work of experts in other fields wherever possible, they relied on the demographers and other purveyors of vital statistics whenever possible, assuming that these learned scientists knew what they were doing, and where the growth patterns were heading.

Unfortunately, it seems that they did not know much more about current or future growth activities in their areas of specialization than the highway prognosticators did in theirs. To indicate that this last statement is not merely an expression of prejudice of highway forecasters against other disciplines, the following is cited from Joseph S. Davis, of the Food Research Institute at Stanford University, in an article by Dorn (20, pp. 314-315):

I am ashamed that, like most of my fellow social scientists, I have so long accepted the conclusions of the population specialists with naive faith...it is disheartening to have to assert that the best population forecasts deserve little credence even for 5 years ahead, and none at all for 20-50 years ahead...Population forecasting is not a simple matter. Available techniques do not permit reliable prediction to be made for 5, 10, 20, or 50 years ahead. The best may be far wrong. Our net reproduction rate is not near unity, but has been well above it ever since 1940. It is not reliable as a basis for prediction. There is no assurance of any peak population at any future date. The age structure of the population does not "inherently" point to cessation of growth and eventual population decline. Our major population problems are not prevention of such decline. There is no adequate basis for expecting the fertility rate, or the crude birth rate, to drop to or below the level of the early 1930's and to remain at that low level...planning for food, agriculture, industry, schools, et cetera, can not be safely done on the basis of supposedly expert population forecasts...If we continue to build on the crumbling foundations I have described, we shall have no excuse for consequent errors in our own work.

After he has "reviewed the evidence" in support of Davis' charges, Dorn finds demographers guilty on nine counts, from "giving the impression that projected populations were relatively inevitable and certain" to "being too uncritical of the work of other demographers." (20, pp. 330-331)

He then states:

In summary, the belief that the rate of population growth in the United States is slowing down remains substantially correct. However, the rate at which it is slowing down and the date on which the total size of the population may become essentially stationary now appear quite different than before the war. The possibility of a decline in total numbers before the end of the century seems unlikely,

although we should not forget that the birth rate can decline just as rapidly as it can rise (20, pp. 331-332).

In conclusion Dorn says: "The estimation of population for periods as short as even five years in the future probably will become increasingly difficult unless economic conditions remain stabilized."

He says also that it remains to be seen whether a continuation of the present or even a rising standard of living will result in a permanent rise in the average size of "completed" families. He closes, however, with the reminder that it is well to remember that past experience shows future events have little respect for the opinions of demographers and economists alike.

A graphical representation of some of the failures in forecasting the total population of Continental United States is given in Figure 4. Present indications are that the actual population is outrunning even the most optimistic better-known forecasts. A real showdown will come later this year (1960) when all the population returns are in from the Eighteenth Decennial Census.

Figure 4 provides an excellent clue as to why so many past forecasts of motor vehicle registrations and travel that were tied in with population projections have been so low. And when it is considered that it was necessary for highway forecasters to segment, subdivide, or otherwise modify these over-all forecasts for purposes of making their predictions (for example, break down, pull out, and project age-group or rural-urban distributions of total population), it is surprising that they were able to do as well as they did in forecasting trends in motor vehicle ownership and use.

There is one characteristic of the population situation that redounds to the benefit of the highway demand forecaster. This is that, except for a negligible amount of immigration, all of the persons who can be potential drivers within the next 15 years or so are already in the population. Thus, the rise or fall in the future birthrate can be completely disregarded in estimating the number of persons who can be potential motor vehicle operators within that period of time; all that is needed is to apply reasonable factors to this total to take account of those already born who will become of driving age each year, and those who will emigrate or die each year.

Assuming that the 1960 Census entails no major revision of 1958 and 1959 estimates of population composition, the universe of potential motor vehicle operators against which the highway forecaster will need to project his vehicle ownership density trends is thus already established (21).

State and Local Forecasts.—What has been said so far has pertained only to the forecasting of the inhabitants of Continental United States as a whole. At that level,

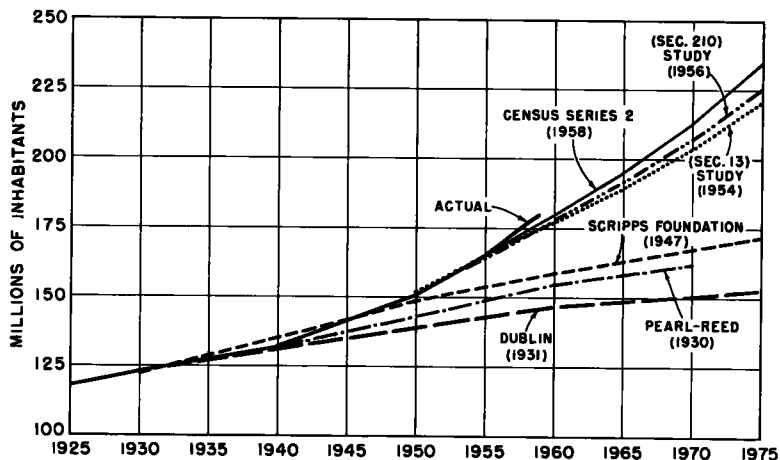


Figure 4. Comparison of selected population projections, 1931-1958, with actual population trends, 1920-1959.

in- and out-migration are relatively small and are generally rather accurately known. Because there are no bars to migration among or within the states, and statistics on such movements are not customarily kept, the forecasting of the inhabitants of a state, a city, or a metropolitan area becomes fraught with many additional problems not found at the national level.

In certain states, and in some localities, more or less successful efforts are made to keep track of such movements in addition to the normal recording of births and deaths. A few states even make state-wide censuses between the Decennial Census years. Often these activities are centered in a state bureau of vital statistics, or in some college or university. The U.S. Bureau of the Census, upon request, will make special censuses of cities or metropolitan areas, the cost of which is borne by the agency requesting the census.

A recent example of the excellent work in population forecasting that is being done in some of the states is found in the report (22) prepared in 1959 by the Planning Department of the North Carolina State Highway Commission. Forecasts of total population were developed for the state as a whole, for each of the three principal geographic regions, and by counties grouped according to major market areas within the state. The report includes a series of tables and graphs and a text which summarizes the projections; describes the background of the study; discusses the various predictions and other relevant data; and explains the methodology, assumptions, and the supporting data and logic used in making the projections.

Per Capita Ratios of Vehicle Ownership and Travel.—The long-term downtrend in the birthrate and the net reproductive rate, accelerated during the depression, and forecasts of a stationary population were widely accepted during the 1930's (23). Projections of travel and motor vehicles made at that time were often based on travel-per-capita ratios and registrations per capita, but the rapid increase of motor vehicles in relation to population of driving age simply was not anticipated. As Figure 5 shows, the slope of the line representing this relationship turned up after 1933, and except for a brief hesitation during the sharp recession of 1937-38, has continued up sharply both before World War II and again thereafter. During the war the density of ownership dropped significantly because of the unavailability to civilians of new motor vehicles.

It is evident that this ratio is affected by both the nature and the level of economic activity. The rise in the ratio diminished in 1951-52 (Korean Conflict), in 1953-54, and again in 1957-58. Although the chart appears to indicate some recent slackening in the growth rate of the key ratios of total motor vehicle and passenger car registrations to driving-age population, there is ample evidence of an upturn in 1959 in all of

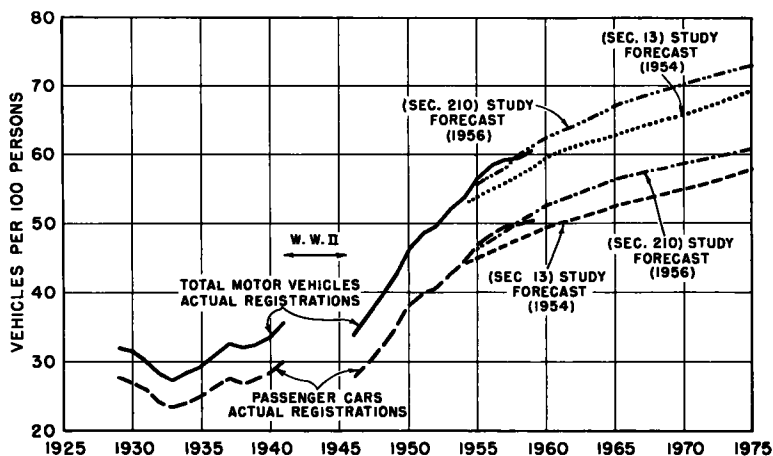


Figure 5. Number per 100 persons of driving age of all motor vehicles and of passenger cars; actual registrations, 1929-1959; estimated registrations, 1957-1975.

the current indicators. The striking thing about the chart is the sharp increase in vehicles per person of driving age in the postwar period. Undoubtedly the major contributing factor has been larger real incomes, especially those in the lowest and middle ranges.

Per capita ratios of motor vehicle ownership have basic value in forecasting, and their use in that capacity should be continued. However, they must not be used without due consideration being given to all of the internal relationships that affect them, such as the proportion of total population of legal driving age, the rural-urban composition of the population and the real-income status of major segments of the population.

Most highway economists and planners are conservative enough to believe that a saturation point in the ownership of motor vehicles will be reached eventually, after which further increases in total registrations will depend on further increase in total population, and shifts from segments having lower saturation points to those having higher ones. What are these saturation points? No one can safely predict yet what they may be, but the long-term trend lines appear to be stabilizing in some areas of high-density registrations.

It has been believed in some quarters that a practical limit will have been reached when there is one motor vehicle registered for each operator licensed. However, 1957 estimates by the Bureau of Public Roads (24, Table MV-12, p. 53) indicated that this level had already been reached in four states, and the nationwide average then stood at 1.20. Of course the number of licensed operators is still well below the number of potential drivers, so there is yet a considerable degree of expansion possible in that area.

Figure 6 shows how the density of motor vehicle ownership in relation to total population increased between 1940 and 1958 in the United States and in 10 selected states. In the nation as a whole the increase was about 60 percent; among the states shown it ranged from about 10 percent in California to more than 150 percent in Mississippi. It is certain that improved economic conditions in states like Mississippi, Louisiana, and Kansas had much to do with the great increases shown for those states. It seems logical to assume that the greatest future gains in density of motor vehicle ownership

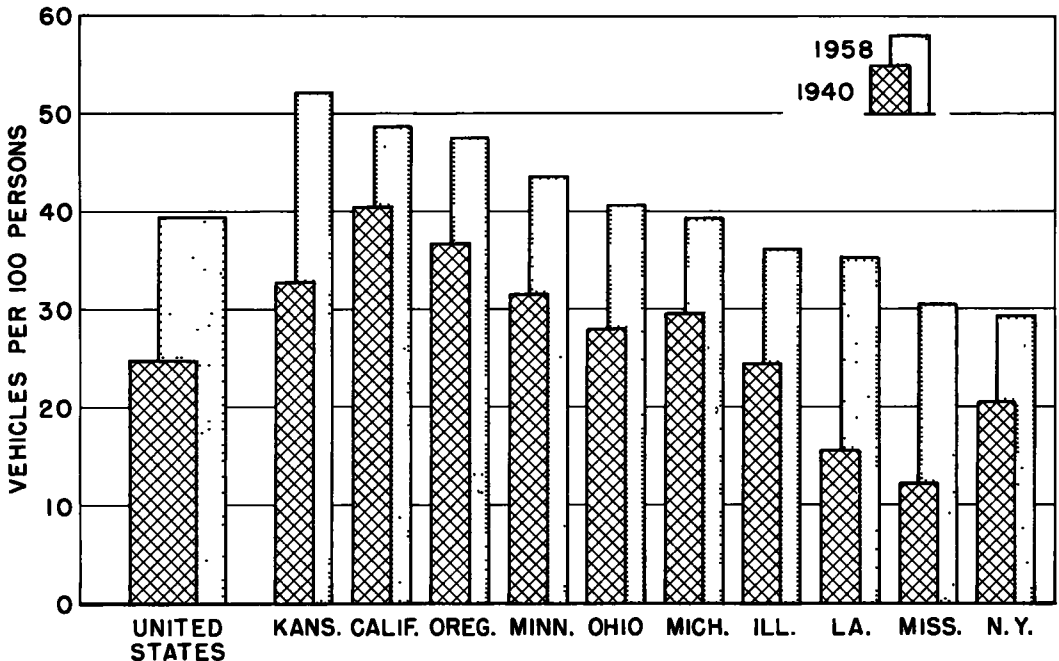


Figure 6. Density of motor vehicle ownership in continental United States and selected states in 1940 and 1958 as indicated by registrations.

will be made in those states where per capita wealth and income have been lowest, providing their economics continue to improve as they have during the past 30 years. Thus, between 1929 and 1957 the percentage increases in per capita personal income were greatest in the South Atlantic, East South Central, and West South Central Census Divisions, while 10 of the 17 states in these three divisions had increases above the national average between 1950 and 1957, and two more had increases exactly at the nationwide rate.

Per capita averages of motor vehicle travel have been used either in making forecasts or in evaluating forecasts already made. However, such averages are not believed to have not displayed the stability deemed necessary for their use as basic determinants of future total highway travel. For such purposes average travel per vehicle, subdivided according to major types of vehicles, appears to be a much more stable and practical factor to use, although it admittedly has certain shortcomings, such as the known tendency of average travel per vehicle to decrease with increases in registration density.

Economic Growth and the Motor Vehicle

As Holmes (10) pointed out in 1950, a close correlation appeared to exist between nationwide vehicle-miles of travel and nationwide economic activity, as represented by gross national product. This parallelism observed between GNP and vehicle-miles for almost 20 years from 1931 onward, had been striking. At the time, recognition of this relationship had a notable effect in raising the sights of traffic forecasters. It may now be desirable to reconsider this relationship, inasmuch as another decade has passed since that observation was made.

Actually, there have been two abnormal interruptions to the growth of traffic since 1929. The first was, of course, the Great Depression, during which automotive traffic held up much better than did income or GNP. Nevertheless, from 1933 to 1942 travel increased more rapidly than did the number of vehicles. During World War II the situation was reversed; GNP and income increased rapidly and registrations held up better than did travel because of the drastic gasoline rationing. Both of these abnormal periods distort the growth trend. Viewing the 1929-1958 period as a whole, travel and registrations have both increased considerably more than GNP in constant dollars—travel by 235 percent and motor vehicle registrations by 156 percent, in contrast to an increase in real GNP of 120 percent. The same result obtains after the automobile "caught up" with the rest of the economy in 1950. Travel between 1950 and 1958 jumped by more than 44 percent, registrations by almost 41 percent, whereas GNP was up only 25 percent. It is obvious that any effort in the past to tie travel to GNP (expressed in constant dollars), except for some relatively short periods or from rather unlike points in the business cycle, would have yielded a low travel estimate.

This situation suggests that perhaps there may be better measures of the demand for highway services than GNP, or else some refinement is required in use of GNP as an indicator. It is known, of course, that both motor vehicle use (travel) and gross national product are measures of the level of activity of the economy, in which respect they are similar. On the other hand, GNP is composed of a number of segments that from time to time have a differing effect on its total level; therefore, these segments are not equally reflected at all times in the demand for highway services. To this extent the two indicators of economic activity are dissimilar. Perhaps there are other economic indicators which will fluctuate much more closely with the demand for motor vehicles and their use than does GNP. Three possibilities that might meet this requirement are national income, total personal income, and disposable personal income.

Data on the first are available at the national level only, and in about the same nature and extent as is the case with GNP. Inasmuch as this indicator has no better possibilities for application at the state or local level than does GNP, it is omitted from further consideration here. Statistics on total personal income are readily available on a state-by-state basis, and not too difficult to obtain for some local areas. This indicator is weak, however, because it does not include certain corporate and other non-personal income which is reflected in the demand for motor vehicles and their use, and

because it includes large sums not available for free expenditure because they are required to pay personal taxes. Disposable personal income, while excluding the areas not covered by total personal income, also excludes those portions of personal income earmarked for taxes. Therefore, this indicator merits further study.

Comparisons of Motor Vehicle Ownership with GNP and Disposable Personal Income

Figure 7 shows the rather surprising fact that since before 1929 there has been no appreciable over-all increase in either the ratio of passenger cars registered to disposable personal income (DPI), or of total motor vehicles registered to gross national product, both shown in constant (1958) dollars. The two principal deviations from normal, 1931-35 and 1940-48, are easily explained. During the earlier (depression)

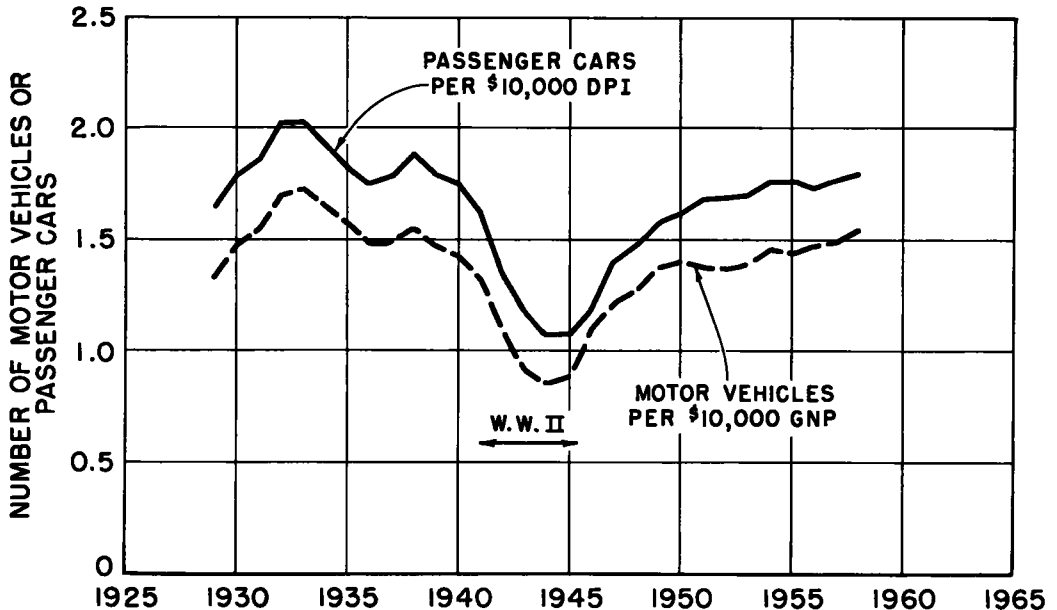


Figure 7. Total motor vehicles registered per \$10,000 of gross national product, and passenger cars registered per \$10,000 of disposable personal income, 1929-1958, both in 1958 dollars.

period both GNP and DPI were falling rapidly, but people were hanging onto their motor vehicles in the hope that better times would come before they had to dispose of them. Their hopes were, of course, justified. During the later (World War II) period both GNP and DPI were rising rapidly, but new vehicles were generally unobtainable, with the result that the ownership ratios fell rapidly until motor vehicles became available again.

Some students of highway economics see evidences of secular (long-term) upward trends in both ratios since 1947. Inasmuch as these trends have now continued rather uniformly at moderate rates for more than 10 years, it is possible that they may be right. However, before deciding to accept such assumptions it is well to remember that both ratios are still only at the approximate levels of 1930.

Automobile purchases and disposable income expended on private automobile (user-operated) transportation have been rising since 1931, except during the war years, and by 1959 were almost twice the levels of 1931. Preliminary information makes it appear likely that in 1959 more than \$36 billion was spent on the purchase of new and used private automobiles, and on repairs, accessories, fuel, and storage. However, the all-time peak in new car purchases of more than 7 million new passenger automobiles, reached in 1955, was not attained in 1959.

In 1959 the average price paid for new automobiles exceeded \$3,000, and by the early fall of 1959 outstanding automobile credit approached \$16 billion, a new record. It also appears that close to 11 percent of personal income after taxes was spent during the year on the purchase, operation, and maintenance of private automobiles—a larger proportion than ever before.

The factors behind these data are too well-known to justify recounting here. What is important, however, is that there is no real evidence that they are diminishing in strength. For example, 16-year old youth will increase sharply in number in three or four years as the postwar baby boom's influence is felt. By 1965 the United States will have at least 4 million additional people 15 to 19 years of age, and probably more than a proportional increase in teenage drivers, unless minimum age limits for operator licenses are raised significantly in the meantime. The population continues to increase most rapidly in suburbia, where automobile ownership is very dense. Despite much speculation, there appears to be no indication whatsoever of any willingness or general tendency on the part of the commuting population to use mass transit in preference to private vehicles, and transit use continues to decline. If the growth of real income is maintained, the factors of demand do not appear to be likely to weaken in the visible future.

A rather comprehensive examination of the earlier postwar forecasts of registration and travel indicates an underlying belief of the prognosticators that the rate of increase in density of ownership would decline within a very few years after the date the forecast was made. Although in recent years the economy has not grown at the rate of 4 percent compounded annually that has been indicated as desirable by government economic planners, traffic has kept up this rate of growth. However, the mistaken idea held before World War II that the saturation point was being approached along the lines of the Pearl-Reed and Gompertz theories of general growth, has not died easily.

Changes in Average Vehicle Use

It is a matter of record that the increase in average use of vehicles which characterized the 1930's has been largely absent in the postwar period. The generally accepted explanation is that the second or any succeeding passenger car in a family is not used as much as a single car, or rather that the use spread over two cars is not double that of the single car. The variously estimated ceilings for average use of vehicles appear to be particularly suspect, however. For example, Schmidt and Campbell (25) cited an estimate that by 1975 or 1985 ceilings on the average rate of use of motor vehicles will have been reached and that they will range only from 10 to 15 percent above 1950 levels, but urged caution in the acceptance of this estimate.

Although this area has been studied intensively, there is still much to learn about determinants of highway use, and there seems little reason to suppose that existing patterns will not change. For example, a change in the length of the workweek would be certain to result in an increase in recreational and leisure travel. Similarly, completion of the Interstate System and other major highway improvements may generate additional travel. It is also possible that the new "compact" cars with their lower price tags and economy of operation may also stimulate increased travel, especially if they encourage more families to join the "multicar" class. Suburban growth in itself is a powerful factor in greater vehicle use, and the length of trip from place of employment to residence is being extended. Thus, there are some strong reasons for expecting growth in average use per vehicle, but these may be counteracted by increases in multi-vehicle ownership, and in density of ownership in low-income groups. Changes in the age-composition of the population also could operate as a factor in this direction.

It is known that average use per vehicle has increased sharply in the past, and it is not unreasonable to expect that this trend may reassert itself in the future as a result of increased leisure, further suburbanization, highway construction, and general mobility. The possibility should not be ruled out.

Recognition of Local Economic Trends

Forecasting of factors relating to the demand for highway services is difficult enough

at the state level, but when the need arises for forecasts at the local level—a county, city, or metropolitan area, for example—the problems become greatly compounded. Such trends as the drift of higher-income families to the suburbs of large cities must be reckoned with. Changes in the industrial or commercial complexions of local areas must also be considered in making forecasts for them.

Fortunately, the forecaster is not entirely left to his own devices in establishing bases or guides for local forecasts. Decennial census data on population are available for all counties, incorporated places, and many unincorporated places, and housing data are available for many governmental units. Intercensal state or Federal censuses are also sometimes available. Local official records of building or demolition permits, utility connections, removals, motor vehicle registrations, and other similar statistics will often aid in establishing trends. State and local records of income, sales, or occupational taxes are also helpful for the same purpose. Forecasters should also make fullest use of city or area master plans; plat records for new housing, commercial, or industrial developments; and of the work of other prognosticators.

Chambers of commerce, other trade associations, civic groups, or colleges and universities often have data at hand or forecasts that will be helpful for projections of motor vehicles, travel, and related items. Marketing journals, atlases, and other similar publications often provide valuable aids for local forecasting.

Highway planners in some areas have been active in forecasting local economic trends, and have produced some excellent results. Among the best and most recent examples are the economic studies conducted under Project 36,100 of the Chicago Area Transportation Study. These have resulted in a whole series of technical reports dealing with area forecasts of trends in various economic indicators, such as employment, income-consumption relationships, consumer expenditures, increases in productivity, and income and taxes. A regional input-output analysis and a final summary report (26) also have been prepared.

Some Numerical Comparisons

Table 1 presents information for selected years about some of the general economic indicators and highway demand indicators discussed herein. For purposes of more accurate comparison both GNP and DPI are shown in constant 1958 dollars. Some of the principal conclusions that may be drawn from this material follow:

1. The annual growth rate of vehicular traffic has been greater than motor vehicle registrations since 1929, but largely because travel seems to stand up better in recession. This fact was borne out most recently in the 1957-58 recession and sharply characterized the Great Depression of the 1930's. This comment does not apply, of course, to the World War II period because of the restrictions imposed on both vehicles and travel.

2. Over the long run both travel and registrations have increased more rapidly than the general economy (GNP) or income after taxes (DPI). In the most recent period, income after taxes has been less subject to recession than GNP and is, therefore, a better indicator of the movement of either traffic or registrations.

3. The growth trends in travel, total motor vehicle registrations, and passenger car registrations have not slackened since 1950, but the annual mileage per vehicle (by implication) has. To a large extent however, this results from multiple car ownership.

It is clear from these data that the growth in the use of the passenger automobile and the truck continues to exceed the growth of the general economy, and there is no indication of leveling off in vehicular growth. The trend in key relationships such as vehicular density in relation to population and average travel should be kept under constant scrutiny.

The relationships presented in Table 1 seem to indicate that passenger car and commercial vehicle registrations increase at about the same rates. However, the characteristics of their use differ so greatly—especially average rates of travel and fuel consumption—that most careful analysts treat passenger cars and commercial vehicles

TABLE 1
COMPARISONS OF NATIONWIDE ECONOMIC GROWTH AND HIGHWAY DEMAND INDICATORS FOR SELECTED YEARS AND PERIODS

Year or Period	Economic Growth Indicators						Highway Demand Indicators							
	Total Population		Population 15-74 Years of Age		Gross National Product	Disposable Personal Income	Total Motor Vehicle Registrations		Passenger Car Registrations		Vehicle-Miles of Travel			
	(x10 ⁶)	%	(x10 ⁶)	%	(\$x10 ⁹) ^a	%	(x10 ⁶)	%	(x10 ⁶)	%	(x10 ⁹)	%		
(a) Amounts														
1929	121,770	-	83,711	-	201.0	-	139.9	-	26,705	-	23,122	-	197.7	-
1941	133,121	-	97,440	-	264.1	-	182.7	-	34,894	-	29,624	-	333.6	-
1950	151,234	-	106,581	-	352.2	-	249.6	-	49,162	-	40,334	-	458.2	-
1957	170,293	-	113,150	-	452.0	-	316.4	-	67,131	-	55,906	-	647.0	-
1958	173,260	-	114,683	-	441.7	-	316.5	-	68,299	-	56,871	-	661.9	-
(b) Change														
1929-1958	51,490	42.2	30,972	37.0	240.7	119.8	176.6	126.2	41,594	155.7	33,749	146.0	464.2	234.8
1929-1941	11,351	9.3	13,729	16.4	63.1	31.4	42.8	30.6	8,189	30.7	6,502	28.1	135.9	68.7
1950-1958	22,026	14.6	8,102	7.6	89.5	25.4	66.9	26.8	19,137	38.9	16,537	41.0	203.7	44.4
1957-1958	2,967	1.7	1,533	1.3	10.3	-2.3	0.1	- ^c	1,168	1.7	965	1.7	14.9	2.3
(c) Average Annual Change ^b														
1929-1958	1,776	1.2	1,068	1.1	8.3	2.6	6.1	2.6	1,494	3.3	1,184	3.1	16.0	4.2
1929-1941	946	0.7	1,144	1.3	5.2	2.4	3.6	2.4	682	2.1	542	2.1	11.3	4.2
1950-1958	2,753	1.5	1,013	0.9	11.2	2.9	8.4	3.0	2,392	4.2	2,067	4.3	25.5	4.5
1957-1958	2,967	-	1,533	-	10.3	-	0.1	-	1,168	-	965	-	14.9	-

^aIn constant 1958 dollars.

^bLess than 0.05 percent.

^cAverage annual percent change compounded.

(trucks, truck tractors, trailers, and buses) separately in making forecasts of registrations and use.

Economic analysts who try to keep their fingers on the pulse of the economy and to chart its future course are coming to depend more and more on electronic computers to help them with the tremendous computation load involved in such studies. Similarly, highway planners and economists might find it to their advantage to program data on highway demand and related economic indicators for electronic computation to assist them in charting trends, making new predictions, and checking up periodically on predictions already made.

TOWARD BETTER FORECASTING

In his admirable text on "Economic Forecasting," Bassie (12) states that the essentials of forecasting are facts, techniques, and judgment. Speaking of judgment, he says further: "It is necessary both in marshalling facts and in utilizing techniques of analysis, but without facts and a technique of analysis no dependable judgment is possible." Perhaps what has been learned from past experience, coupled with available information, improved techniques, and the application of better judgment, may be able to do much in improving future forecasts.

The Lessons of the Past

Because the trends have been so often misinterpreted in the past, prognosticators have been overly conservative. They have failed to recognize fully the cyclical, but nevertheless dampening, effects of the Great Depression, and the revolutionary effect of the automobile in changing basic patterns of American life. Can it now be assumed that changes of comparable magnitude will continue into the future? Obviously, mechanical projections alone cannot yield the answer.

The "standard" or "classical" method of projecting vehicle-miles, for example, has been to give equal weight to changes in population, persons-per-vehicle ratios, and average vehicle use. Obviously, the most influential segment of the population from the standpoint of such forecasts is that in the driving-age group, which for purposes of the nationwide Highway Finance Study and the Highway Cost Allocation Study was considered to comprise the persons between the ages of 15 and 74, inclusive. As already pointed out, except for net immigration that population as it survived had already been born when these forecasts were made; therefore, all that was necessary for a 15-year forecast was to age the population by 15 years. Assuming that vehicle-ownership density and average use of vehicles could have been predicted accurately, there should have been reasonably accurate travel forecasts. As already pointed out,

Figure 2 shows that from the time the Section 13 Study and Section 210 Study forecasts were made until the present the realized annual travel has fluctuated within the band established by these two forecasts, and unless there is some unexpected change in the trend it is likely that they will remain within that band at least through 1960.

In the earlier applications of the classical method of forecasting, little or no advantage was taken of available data on the age-composition of the population. More recent estimates, particularly those made for the Section 13 and Section 210 studies, have utilized available data on this characteristic of the population.

The pre-1950 forecasters of the demand for highways and highway services felt the full brunt of the underestimations of the population that are so obvious in Figure 4. In addition, they were plagued by lack of sufficient experience-information on vehicle ownership density and average vehicle use.

Because, in the population projections with which they were working, births were seriously underestimated, net immigration was understated, and deaths were over estimated, it was unavoidable that all their forecasts based on these predictions would fall sadly short of reality. Both the population and traffic forecasters appear to have been totally unprepared for anything remotely like the increase in births or the sharp rise in automobile registrations of the postwar period; both persisted in arguing that the upturns were temporary postwar phenomena and would soon level off to more "normal" rates. However, the short fall in population estimates can be held accountable for only part of the underestimation in travel, because neither the rise in vehicle density nor the increase in use could be foreseen from data available in the magnitudes in which they occurred. Therefore, it would seem that the principal reason for the notable failure of the so-called classical or standard methods of forecasting insofar as projections of the demand for highways and vehicles are concerned was the lack of proper information upon which the forecasts were to be based rather than shortcomings in the techniques applied. This is not meant, however, to rule out improvements in techniques.

We should have learned by now that with changes in the economic climate changes in vehicle ownership density and vehicle use may be expected, but that in interpreting these changes care must be exercised to separate cyclical from secular trends. Failure to separate such trends, especially during the Great Depression and during the relatively minor recessions of the postwar period, has misled otherwise astute forecasters on both national and state bases. Thus, the effects of the Korean Conflict on the projections of Moses, of the mild recession of 1953-54 on the forecasts made for the Section 13 Study and of DuBrul can be seen in Figure 1. The forecasts of registrations made for the Highway Cost Allocation Study appear to have been more nearly in line with the long-time trend observed since the close of World War II; for that reason the recession of 1957-58 appears to have pulled actual registrations below the trend forecast in a cyclical fluctuation. However, preliminary registration data for 1959 indicate that the line denoting actual registrations is now being brought closer to the forecasted trend line, and a good level of sales of new vehicles during 1960 could bring it still closer.

Availability of Basic Information

Would-be forecasters of indicators of the demand for highways are now in a much better position, from the standpoint of available information, to make accurate prognostications than ever before. The most comprehensive decennial census of the American population that has ever been made will be undertaken in 1960, and preliminary information from this source should begin to be available soon after July 1. The Federal Government provides on an annual basis much more (and more accurate) information than it has ever provided before; included are, of course, the annual "Highway Statistics," a publication of the Bureau of Public Roads; the "Statistical Abstract of the United States," published by the Department of Commerce; the "County and City Data Book," series published periodically as a supplement to the "Statistical Abstract;" and the "Annual Economic Report of the President," submitted to the Congress.

To a varying degree agencies of state and local governments also publish much in-

formation on either a periodic or irregular basis that can be used by highway planners and economists in making forecasts. This includes total population and other vital-statistics information already mentioned, tax collection information (especially sales tax data), and statistics on wealth and income. Information published by public agencies is frequently supplemented by publications by colleges and universities, chambers of commerce, and so forth.

In his work on forecasting, Bassie (12, pp. 27-53) devotes an entire chapter to "Information for Forecasting Use." After citing many of the best known and most readily available sources of statistical information, he devotes the closing section to the search for key data. Here he stresses the importance of maintaining an attitude of open-mindedness that builds good judgment and "assists and protects the forecaster." He stresses the truism that facts are not always what they seem, and that good common sense and careful investigation are necessary to their proper interpretation.

Techniques and Their Application

As indicated by Schmidt and Campbell (25, pp. 174-199), forecasting procedures may be generally classified into two groups, mechanical and analytical. They quote Grant as stating that the mechanical method simply projects forward the composite past trend on the assumption that future experience will be a direct function of past experience. In defining the analytical method they state that it "classifies and analyzes the several related components or influence factors that have formed the historical trend pattern, taking into consideration developing stimuli which will become influential in the future. The analytical method recognizes that simple extrapolation for a long-time period may lead to absurdities." Although their assignment of certain methods under one or the other of the two procedural types might be questioned in some degree, there is no disagreement with their basic definitions.

There are situations under which mathematical projections of past trends to indicate what may be expected in the future are most logical and desirable. However, the limitations of mathematical functions must be kept in mind; forecasters in other areas, such as demography, along with forecasters of the demand for highway services have failed badly in the interpretation of future trends by basing their projections on the logistic- or Gompertz-type curves. The equations of both curves are admirably fitted to the projection of certain types of growth trends when certain basic requirements are met. When these requirements are not met, projections based on these equations are certain to be in error.

If it can be assumed that the country is still in the rapid-growth period of the automobile age, long-range forecasting will probably fare better if analytical rather than mechanical methods are followed, or if some combination of the two is adopted. This is not meant to rule out straight-line or compound-interest types of projections where such appear to be applicable. It does mean that if such projections are to be used the basis of their application will be primarily analytical rather than mechanical. Furthermore, it would seem that for most long-range purposes the projection or forecast needs to be complex rather than simple, although the simple type of projection might be entirely satisfactory for short-term forecasts. By a simple projection is meant one in which only one related variable or trend is taken into account, as is the case when forecasts of travel are based entirely on trends of motor fuel consumption, as has sometimes been done. A complex type of projection is one in which the concomitant interaction of a number of variables is taken into account either directly or indirectly. The so-called "standard" or "classical" method of forecasting is of this type. On the other hand, a forecast of motor vehicle travel based only on the trend in gross national product would be of the simple type.

Lindman (27) proposes three procedures which he says "have been developed for injecting economic factors into forecasting for state highway-study purposes, two of them projections and one a forecast." His first procedure, which is a simple projection, is to take a state economic index, such as personal income, and determine its historical relationship to motor vehicle registrations and travel; project the index; and then project both motor vehicle registrations and travel on the basis of that

relationship. His second proposed procedure would be to "take a national economic forecast such as personal income or GNP, relate a state index such as personal income to it, and project the state index on the basis of its historical relation to the national index." The desired state forecasts of registrations and travel can then be projected by relating them to this projected state index. He cites as the basic weakness of this procedure that the assumed continuation of fixed relationships in a given state can cause major errors.

His third and "most comprehensive procedure is to take the national economic forecast of GNP and national personal income, study the prospects of the major sectors of a state's economy in relation to these forecasts, and prepare a state forecast" based thereon. The basic obstacles to adopting this method of forecasting appear to be the difficulty of obtaining adequate data on state economic indicators in some states and the amount of work involved in making the forecast.

It is not the purpose of this paper to recommend any specific methods of making forecasts or projections. Many acceptable methods are available; as previously indicated, the method to be selected in any given instance should be that which appears to meet most completely the requirements of the situation. This does not mean that better methods of forecasting factors relating to the demand for highways and highway services cannot be devised; in fact, further formal study of forecasting techniques could well be undertaken under the auspices of a special committee of the Highway Research Board.

Applied Economic Analysis

Much has been said throughout this paper about the important role played by judgment in the making of forecasts or projections. Judgment alone, however, is not enough. To judgment must be added careful attention to detail; this includes not only the detail of the various indicators considered but also the detail required in the application of the chosen forecasting method.

No better concise statement of what is required in this respect can be found than the following paragraphs with which Bassie (12, p. 144) closes his discussion on the construction of over-all forecasts:

This discussion of approaches to over-all forecasting may be concluded by stating that good forecasting is just sound economic analysis. Such analysis must conform with our best understanding of the forces that make the economy move, it must evaluate those forces in quantitative terms, it must take into account sufficient detail to encompass important special knowledge of independent movements or unusual developments in various parts of the economy, and it must systematically fit together and reconcile the diverse hypotheses that arise in the process.

It follows from this that forecasting based on the realities of the situation is no easy task. It requires close attention to detail, sufficient familiarity with methods to discriminate between the valid and invalid, and constant application to the solution of problems that arise in the process of assimilating new information and adapting techniques to new situations. There is no alternative to working through the chores that alone offer a means of keeping abreast of developments in order to put together the structure of quantitative projections that makes up a sound over-all forecast.

Of course, there can be no assurance that a valid conclusion will be reached—or, once reached, that it will not be set aside in a short time by some unpredictable disturbance. Any forecast is subject to error. In any given situation a soundly based forecast may have only a little higher probability of success than

one made by some shortcut procedure without nearly so much hard work. Year in and year out, however, the difference may be all-important. The test of any method that can at best establish only a probability lies not in any single success or failure but in consistent results over an extended period of time.

CONCLUSIONS

We conclude on an optimistic note: There is no longer any reason why there should be failure in forecasting highway demand factors. The analysis included herein has led to the conclusion that many of the more recently made forecasts of motor vehicle registrations, travel, and other indicators of the need for highways and highway services have actually been rather successful in serving the purposes for which they were made. Taking into account the nature and amount of basic information that is now available—not only at the national level but also at state and local levels—and the analysis methods that can be applied, there seems to be no need for future failure in this type of forecasting if the forecasts are made intelligently and with due consideration being given to all essential factors. Highway economists and planners must recognize the need for inter-disciplinary cooperation in making forecasts, particularly long-range prognostications, and for frank recognition and evaluation of past failures. It must be recognized also that no long-range forecast must ever be regarded as completed; continuing re-evaluation at periodic intervals is essential to measure the acceptability of such forecasts and to permit modification whenever conditions appear to warrant.

One final note of caution should be sounded. In the game of forecasting, the rules are often changed while the play is going on. Important changes in the basic economic and social structure (such as those brought about by a war or a new invention) which could not have been foreseen by the forecaster may enter the picture at any time to nullify his projections. To paraphrase Dorn, it is always well to remember that past experience shows that future events have little respect for the opinions or prognostications of highway planners and economists alike.

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Discussion

NATHAN CHERNIACK, Economist, The Port of New York Authority. — The authors conclude that "There is no longer any reason why there should be failure in forecasting highway demand factors." In effect, they have said: "Eureka! We have at last found the crystal ball."

Later, however, they restated their optimistic conclusion in this way: "---there seems to be no need for future failure in this type of forecasting if the forecasts are made intelligently and with due consideration being given to all essential factors."

Diligent search was made throughout the paper for supporting illustrations of this conclusion in the form of forecasts of vehicle registrations for the United States, or for selected states, for the years 1965, 1970, 1975 and 1980. The authors could have prepared such forecasts, and they certainly would have been "made intelligently and with due consideration being given to all essential factors." But no such forecasts were found. Instead, only criticisms of past forecasts were found.

Having had some experience with forecasting vehicular traffic in connection with toll bridges and tunnels over the past 35 years, and having exchanged techniques with professional forecasters, the writer can assert that there is an unwritten law among professional crystal gazers to the effect that the time to criticize forecasts is when they are made, not after the forecast period is past. The only statement that is permitted one after the forecast period has expired, if it would make him happy, is: "I told you so." Comparing recorded figures with comparable forecasts based on time extrapolations, and then calculating percentage under or over estimates, is therefore merely a clerical exercise—not a professional contribution.

The authors examined a number of vehicle registration forecasts, based on extrapolations of time series that made use of various types of mathematical time functions. Time functions may range from "straight lines," to "compound interest curves," to

S-shaped curves like "Gompertz" or "Pearl-Reed" types. Such mathematical extrapolations of time series, by their very nature, do not permit of contractions in vehicle registrations like those that were experienced during World War II under gasoline rationing. All such time functions assume that growth in the future will depend on the mere passage of time. No matter by what type of time function one might choose to express past growth, one would never be sure that it would continue into the future along the same function. This is particularly so when, in the early years, the various types of curves are not significantly different from each other.

The authors state: "---therefore, all that was necessary for a 15-year forecast was to age the population by 15 years." Here was an opportunity for the authors to make a professional contribution by taking their own advice—namely, aging the population figures and translating them eventually into future vehicle registrations. Had they dirtied their hands with actual available statistics to acquire experience in how to effectuate their own advice, they would have encountered a number of statistical frustrations in the process. They would have come across incomplete and inadequate historic data, such as lack of registrations of births in a number of states, as well as under-registrations of births in states where such data were available; lack of data on deaths by age groups and on net migrations; only a limited series of historic data on licensed drivers; and, finally, extreme difficulty in developing correlations for translating young persons of driving age into potential auto drivers and then, in turn, translating those drivers into vehicle registrations.

The authors go on to say: "Assuming that vehicle-ownership density and average use of vehicles could have been predicted accurately, there should have been reasonably accurate travel forecasts." In effect, the authors are saying that, assuming they had an egg, they could have had a ham and egg sandwich, if they had ham.

The authors caution the prognosticator to distinguish between cyclical fluctuations and secular trends. There is still a paucity of long-term traffic data except at toll facilities. Consequently, he is a wise prognosticator who can currently (not after the fact) distinguish a temporary cycle from a permanent change in the trend.

Also, he is a wise prognosticator who can distinguish between expansions in travel which reflect organic growth resulting from an expanding number of auto drivers, and those that result from rises in living standards, and those that result from reductions in travel impedances or from significant travel improvements.

The authors further state that "would-be forecasters of indicators of the demand for highways are now in a much better position, from the standpoint of available information, to make accurate prognostications than ever before." Here was another opportunity for them to demonstrate how accurate their forecasts of vehicle registrations could really be, by utilizing all the available information at their command at their very doorstep in Washington.

Again, the authors mention various types of information now available by the Federal Government. How far can one go in developing more effective techniques for forecasting registrations or travel with the aid of the types of summary data contained in the documents mentioned by the authors, before one faces the need for more detailed information not so readily available, if at all?

The authors also mention sources of information published on either periodic or irregular bases by agencies of state or local governments, and publications by colleges, universities, chambers of commerce, and so forth, and suggest that all such data can be used by highway planners and economists in making forecasts. The writer believes that there is a crying need for uniform and detailed data on state and county vehicle registration and travel determinants (not now available), compiled by the Federal Government, so that vehicle registrations and traffic forecasts for the states, metropolitan areas and cities may be comparable throughout the nation. The very comparability, based on uniformly compiled Federal data, would greatly improve forecasting techniques and at the same time supply the needed confidence in forecasts which must serve as the economic foundations for billions of dollars worth of interstate highway projects.

Even if one were to be completely devoid of humility, he could assert that there is still a long road to travel before it is possible to be as optimistic as the authors are,

and also say that all the reasons for failing to produce reasonably accurate forecasts in the future have now been exhausted.

E. L. KANWIT, C. A. STEELE, and T. R. TODD, Closure—Mr. Cherniack's comments boil down to five major "charges", as follows:

1. The paper failed to produce any new forecasts; the authors didn't practice what they preached.
2. The evaluation of previous forecasts was not only unfair but also "merely a clerical exercise—not a professional contribution."
3. Available data on population, registrations, travel, etc., are incomplete and inadequate; the authors appear not to know this.
4. It is difficult to distinguish between cyclical fluctuations and secular trends.
5. In their naive optimism over the future of forecasting the authors are devoid of humility in concluding: "There is no longer any reason why there should be failure in forecasting highway demand factors."

Mr. Cherniack apparently missed much in the paper, and distorts and lifts out of context most of what he chooses not to overlook. His five points are considered in the following.

1. The purpose and scope of the present paper are limited. The purpose is clearly stated as being "...to examine previous forecasts, with the aim of determining if they were inadequate to serve the purposes for which they were made; if so, why and to what extent; and what might be done toward making better forecasts." The authors "...lay no claim to having developed applicable solutions to the major problems that confront all forecasters of economic data. That task is left for the HRB Committee on Economic Forecasting..." The undertaking of new forecasts was not within the scope of the paper.

However, two of the authors were intimately connected with the Bureau of Public Roads review, analysis, and summarization of forecasts of vehicle registrations, travel and related items recently prepared by the state highway departments in response to Congressional directives contained in Section 13 of the Federal Highway Act of 1954 and Section 210 of the Federal Highway Revenue Act of 1956. Both forecasts are shown graphically and discussed in the paper. By "reading between the lines" it may be concluded that the authors' personal opinion is that, barring some unforeseen contingency, future nationwide registrations, travel, and related items (such as fuel consumption) are likely to reach levels somewhere between those predicted pursuant to the two directives between now (1960) and 1975.

2. Perhaps unfortunately, not all students of forecasting, including several cited by the authors, agree with Mr. Cherniack that "the time to criticize forecasts is when they are made—not after the forecast period is past. The authors attempted a strictly objective study to determine why, almost without exception, preceding forecasts of factors relating to highways and highway use made on a national or state basis have been too low. To do this they believed it necessary to compare past forecasts with realizations and, by studying how the forecasts were made wherever possible, and the conditions under which they were made, determine why these predictions failed or were successful.

3. The authors are well aware of the serious inadequacies in published information on population, vehicle registrations, motor vehicle travel, and other pertinent statistics. They are also aware, however, of the many rich veins of statistical ore that have not yet been mined (published) completely, but which, with a little careful digging by the researchers, will yield pay-dirt. The authors were addressing their remarks primarily to competent, experienced research workers who must share their own feeling that research is made more challenging when not all the tools nor all the building materials are immediately at hand; and who are willing to exercise a little ingenuity in making the best of what is available.

A careful reading of the paper will disclose that nowhere is the statement made that all the data needed for forecasting highway demand are at hand. Instead, the statement is made repeatedly that more pertinent data of many types are now available than has

ever been the case before, and that therefore the competent forecaster, making good use of this information and of his own abilities, can produce reasonably adequate (successful) forecasts, providing no major changes in the existing "balance" of the economy occur during the period for which his forecast is made.

4. The authors are well aware that it is not always easy or even possible to make "at-the-time" distinctions between cyclical and secular trends. However, an alert highway economist should not have had difficulty in diagnosing the 1955 new-car sales boom as a purely cyclical fluctuation resulting from concerted sales drives, involving price cutting, by the manufacturers. Similarly, on a nationwide basis the 1958 recession could be readily diagnosed by the experienced practitioner as a cyclical phenomenon, although in a few states its effects, taken in combination with other local conditions, may be more lasting.

When all circumstances are carefully considered, however, on a national basis, and similarly for most states, it should not ordinarily be difficult for an economist of Mr. Cherniack's experience to distinguish between recession and depression years. The authors' thesis that the trends in registrations on travel must be interpreted from similar points in the business cycle is rather elementary, but worth emphasizing because it has often been ignored.

5. The authors are well aware of the truth of the old adage that should be the motto of every researcher: "Ignorance presumes where knowledge is timid." This is the main reason why the paper is studded with cautions—warnings of the need to watch for changes in trend, of the dangers in any economic forecasting, and of the need for constant reappraisal.

Nevertheless, the authors dare to believe, Mr. Cherniack to the contrary, that better forecasts should, can, and will be made in the future, and that the dismal errors of the past need not be repeated. To expect less would be to admit that highway planning is a hopeless task. Actually, some of the most significant efforts in the field of transportation forecasting in recent years have originated in the very agency with which Mr. Cherniack is associated. The authors confidently expect that the new HRB Committee on Economic Forecasting will possess heavier technical armament than the crystal ball he mentions and will approach the problem with the humility he seeks.