# FORECASTING URBAN TRUCK TRIPS IN THE UNITED KINGDOM

D. N. M. Starkie, University of Reading, England

In the light of recent circumstances, the paper considers the bases of forecasts of urban truck activity made by transportation studies in the United Kingdom during the 1960s. Particular stress is placed on the importance of control totals, which derive from estimates of national truck activity. Their development appears to have ignored certain trends in the economy and, more specifically, significant changes in the productivity of the truck industry during the last few years. The opinion is proffered that the separate estimates made of zonal truck activity in transportation studies (estimates that are subject to the constraint imposed by the control totals) are characterized by poor statistical analyses. There is evidence that the basic assumptions of linear regression, the preferred method of analysis, are frequently ignored. In conclusion, it is suggested that more attention should be given to the development of adequate control totals and to methods of analysis that consider nonlinearities in zonal truck data.

•IN THE LAST FEW YEARS, the movement of freight in urban areas has become an important transport planning issue in the United Kingdom. There are a number of reasons for this, including the current emphasis on traffic restraint in urban areas, environmental factors, and the stress now placed on the economic appraisal of transport plans. Trucks are less responsive than automobiles to restraint measures; they are seen as environmental villains (currently an emotive issue in the United Kingdom), and the high values of time and cost of operating trucks add to their economic significance. For these and other reasons it is arguable that, in urban areas, freight forecasting is now of more importance than modeling person movements.

The approach in British transportation studies to forecasting urban truck movements has been, in essence, to adopt the fundamentals of the paradigm used for the modeling of person movements. This paradigm traditionally revolves around four separate but interrelated stages of trip generation, distribution, modal split, and assignment. In an urban context, the issue of freight modal split is of little importance, whereas the distribution and assignment stages present no fundamental problems of modeling peculiar to trucks. Although consideration in some studies of these two latter aspects has been rather elementary, this generally signifies a lack of interest and effort rather than profound difficulties of a conceptual kind.

It is when we consider the trip end stage, however, that the methodological contrast with person movement is most apparent and the impact on the final forecast most significant. It is, therefore, largely with this crucial stage, of estimating trip ends, that this paper is concerned.

## CONTROL TOTALS

There are two particular procedures that constitute the forecasting of trip ends. First is the prediction of a local control total relating to the overall freight activity in the area studied, and the second is the calculation of movement at the zone level. The independently determined control is used subsequently to constrain the estimates of freight activity derived from the (zonal) trip end model. It is used as a basis for a scaling factor, and its importance can be judged from the fact that in one major transportation study adjustments applied to zonal trips, to match their overall total with the control, alone accounted for 80 percent of the growth in trip end volumes.

The reason for significance of the control is that time-dependent influences on trip generation, e.g., changing vehicle technology, are not as a rule explained by variables used in the trip end model per se. These latter variables traditionally summarize land use characteristics and, therefore, tend to take account only of land use changes. Not only is their specification weak for true forecasting, but they do not allow various policy options, such as restriction on hours of delivery and on vehicle size, to be considered in detail. As a consequence, the control can be a vital means for overcoming these conceptual problems. Indeed, it is the only way some fundamental policy issues can be examined at the present time.

The usual basis of the control is a forecast of the national vehicle stock. It is then assumed that local trips will increase proportionally. The presumption therefore is that the local and national economies will have similar rates of growth and that trips per vehicle will remain constant.

One frequently used method of developing the national forecast has been to extrapolate recent trends in truck registration. However, trends in the United Kingdom since the mid-1960s have been contrary to the established trends of earlier years. Quite apart from the paradoxical situation of projecting supply instead of demand, this reversal serves to warn against the use of such facile methods (Table 1).

An alternative to such simple extrapolation of an overall trend is to develop a quasi demand-supply relationship. In essence the basis of this approach is

$$\left(\frac{\Delta \text{ total ton-miles by highway}}{\Delta \text{ ton-miles per average vehicle}}\right) = \Delta \text{ vehicle stock}$$

where Δ represents the change.

In this approach the demand factors supposedly operate in the numerator and the supply aspects in the denominator. The usual practice here is to treat these two aspects as though they were totally independent of each other. Nevertheless, in a true econometric model the demand and supply conditions are very much interdependent. Demand is partly a function of the truck industry's supply cost. New methods of operation, or new transport facilities that reduce these costs, stimulate demand by the substitution of more transport-intensive factors for less transport-intensive factors in production and by broadening market areas for the final products. This suggests that a proper approach to the issue as a whole would be to use a more general approach, perhaps within the context of input-output analysis. However, for the moment we shall adopt a partial (and traditional) view and consider the demand and supply conditions separately. But, as we shall see, there are indications that significant interactions do exist even within the moderate forecasting period that characterizes contemporary transport studies.

## TRENDS IN DEMAND

In the past 2 or 3 years one or two studies have been conducted in the United Kingdom that have analyzed the statistical relationship between the annual growth of the U.K. economy and the annual volume of inland freight transport (1, 2). A feature of these studies has been, on the basis of their poor statistical correlations, their limited success at fully explaining the situation on a year-by-year basis. Presumably this weak relationship is partly due to the fact that, because the economy expands and contracts at different times, different industries with differing transport inputs are affected. Whether some form of lagged time series analysis would improve the results remains an unexplored research field. Meanwhile, the argument has been that "there is no reason to doubt the established long-term relationship between Gross Domestic Product (GDP) and the demand for freight transport" (1). Nevertheless, we may note, as an aside, that it is in this long-term context that the independent treatment of the demand and supply aspects is less justifiable.

There may be, as some have argued, no reason to doubt the long-term relationship between GDP and freight transport demand. But discovering this relationship exactly is perhaps more difficult than is commonly supposed. An early study of this subject in the last decade by Hall (3) concluded that the volume of freight could be expected to grow more slowly than GDP and that this disparity would be less the faster the economy grew. The results of Hall's analysis were approximately consistent with the forecasts contained in a Ministry of Transport report (4) published nearly 5 years later. However, they were very much at variance with the findings of a 1964 study (5) (Table 2). Chisholm (6) has recently extended this type of analysis principally by taking a longer time series. His analysis showed that a 2.7 percent increase in GDP from 1953 to 1968 gave rise to an annual increase in all freight of 2.2 percent and a ratio of 0.82, one higher than the corresponding ratio used for forecasting in Hall's study.

One reason perhaps for some of these apparent contradictions is that a change has been taking place in the long-term relationship between economic growth and freight transport. Beckerman and Associates noted that prior to 1957 the tendency was for freight movements to expand at a slower rate than the economy. Tulpule (7), analyzing later statistics, suggested that between 1958 and 1963 the amount of freight traffic and GDP increased by similar proportions, whereas after 1963 ton-miles grew at a faster rate than GDP. This evidence strongly suggests that the underlying trend in the United Kingdom is toward a more transport-intensive economy.

It is difficult therefore to share the confidence of some (6) that a simple linear correlation between GDP and freight ton-miles provides an adequate indication of the future demand for freight transport services. Until we disentangle the underlying trend it is difficult to share Sharp's optimism that a stable long-term relationship exists.

It is perhaps an interesting comment that the period during which the British economy appeared to change from a position of inelasticity to one of elasticity, in terms of the associated transport coefficient, was a time of rapid growth of investment in highways and a time when structural developments in the truck industry meant that freight rates were falling in real terms (8). Once again it places stress on the interrelated nature of the demand and supply forecasts involved, when growth in the number of freight vehicles is predicted.

## TRENDS IN THE SUPPLY FACTORS

Let us now turn to the supply side of the equation. Of interest here is the influence of public policy and, in particular, the effect it has had on the use and carrying capacity of the average vehicle.

A feature of the last decade has been a rapid change in policy with regard to regulations governing the construction and use of trucks. Table 3 gives a chronological selection of these changes.

In addition, there have been changes in taxation policy bearing either directly or indirectly on the truck industry. And, more in the background, but not without significance, there has been continual technological progress such as the improved design of tractor-trailer combinations.

The apparent effect on the truck industry of these developments has been dramatic (Table 4). In spite of large increases in average vehicle carrying capacity, load factors have fallen only slightly. This together with an increase, albeit small, in the annual miles run per vehicle has produced a very large increase in vehicle productivity.

The extent to which such increases in productivity are to continue would appear to be very much a matter for transport policy. If, as it seems reasonable to assume, larger trucks have been instrumental in boosting the trucking industry's productivity because of changes in the construction and use regulations, future increases in this productivity are by no means ensured. The recent public reaction to the detrimental environmental effects of larger trucks has been too pronounced for this to be assumed with certainty. And yet the correct prediction of changes in productivity could be a vital factor in determining the total size of the truck industry. Calculations by Sharp illustrate this and are given in Table 5. These calculations show, for instance, a difference of a million trucks by the year 2000 if, instead of stagnating, carrying capacity (and its utilization) grows at 2½ percent per annum.

We can thus appreciate that the future national stock of trucks is the outcome of the interplay between a large number of factors. The situation is exceedingly complex and

**Table 1. Indexes of the number of registered general freight vehicles in Great Britain (excluding Northern Ireland).**

| Date | Unloaded Weight | | | |
|---|---|---|---|---|
| | <1½ Tons | 1½ to 3 Tons | >3 Tons | Total[a] |
| 1960 | 100 | 100 | 100 | 100 |
| 1961 | 104.9 | 94.8 | 114.3 | 103.9 |
| 1962 | 107.1 | 89.1 | 122.7 | 105.3 |
| 1963 | 111.6 | 87.4 | 135.3 | 109.5 |
| 1964 | 115.3 | 83.6 | 147.1 | 112.6 |
| 1965 | 114.3 | 77.3 | 155.0 | 111.9 |
| 1966 | 111.8 | 70.7 | 161.8 | 110.0 |
| 1967 | 115.6 | 69.3 | 171.0 | 112.9 |
| 1968 | 110.6 | 64.7 | 173.1 | 109.8 |
| 1969 | 116.4 | 58.0 | 172.7 | 111.3 |
| 1970 | 123.2 | 56.6 | 176.9 | 115.6 (111.1) |
| 1971 | 124.3 | 54.3 | 178.6 | 115.9 (111.3) |
| 1972 | 129.4 | 54.6 | 172.3 | 117.7 (113.3) |

[a]After 1969 the Post Office Corporation's vehicles were no longer exempt from licensing. The index in parentheses continues the series minus the number of Post Office vehicles that entered the statistics in 1970.

**Table 2. Growth in freight traffic related to growth in U.K. economy.**

| Study | Date | Analysis Period | Forecast Period | Type of Freight | Ratio of Growth of Inland Freight to Growth in GDP | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Actual | 3 Percent GDP Growth[a] | 3.5 Percent GDP Growth[a] | 4 Percent GDP Growth[a] |
| Hall | 1963 | 1952-60 | | General | 0.9 | | | |
| | | | 1960-80 | General | | 0.9 | | 1.2 |
| | | | 1960-80 | All | | 0.65 | | 0.85 |
| Beckerman | 1964 | 1952-62 | | General | 1.48[b] | | | |
| | | | | All | 0.94[b] | | | |
| | | | 1960-75 | General | | | 1.23 | |
| | | | 1960-75 | All | | | 0.94 | |
| Chisholm | 1971 | 1953-68 | | All | 0.82 | | | |
| MOT | 1963 | | 1966-75 | General | | 1.00 | | |
| | 1967 | | 1966-75 | All | | 0.60 | | |

Note: There are slight differences in the base statistics or assumptions used; e.g., Beckerman's all freight estimate excluded freight by passenger railroad, but these are not considered to account for the substantial differences between the statistics shown.

[a]Assumed.

[b]Based on rate of increase in GDP experienced during 1950-60.

**Table 3. Changes in regulations relating to construction and use of trucks in the United Kingdom.**

| Date | Regulation Change |
|---|---|
| 1962 | Speed limit raised from 30 to 40 mph for trucks over 3 tons (unloaded weight) |
| 1964 | Permitted maximum weight and size of tractor trailer combinations raised from 24 to 20 tons gross and 35 ft to 42 ft 8 in. |
| 1968 | Permitted maximum size of tractor trailer combinations raised from 48 ft 8 in. to 49 ft 2 in. |
| 1968 | Trucks less than 1½ tons (unloaded weight) released from all licensing restrictions on carriage |
| 1970 | Abolition of the need for a second driver for truck and trailer combinations |
| 1970 | By December all trucks freed from carriers licensing |
| 1971 | Speed limit raised from 40 to 50 mph for trucks under 1½ tons (unloaded weight) |
| 1972 | Permitted maximum weight of "rigid" trucks raised from 28 to 30 tons |

**Table 4. Capacity utilization of heavy trucks.**

| Date | Average Carrying Capacity (tons) | Miles per Truck | Average Ton-Miles per Truck | Tons Carried per Truck-Mile | Tons Forwarded per Capacity Ton-Mile | Ton-Miles per Capacity Ton |
|---|---|---|---|---|---|---|
| 1960 | 4.67 | 16,400 | 43,000 | 2.99 | 0.65 | 10,600 |
| 1965 | 5.71 | 17,400 | 63,400 | 3.64 | 0.64 | 11,100 |
| 1969 | 6.79 | 18,600 | 77,900 | 4.19 | 0.62 | 11,500 |

very difficult to forecast with confidence. Nevertheless, even though precise statistical analysis of relevant variables might be absent, common sense tells us that we should take account of these factors if only by guessing their effect on the overall situation. Whether U.K. transportation studies have done so is a subject to which we now turn.

## CONTROL TOTALS IN TRANSPORTATION STUDIES

The situation for some of the recent and larger studies is given in Table 6. It merely gives a broad indication, inasmuch as the methods used varied widely and they did not conform to a standard pattern. The important columns are 4 and 9. Consideration of the latter, for example, implies some consideration of columns 6, 7, and 8, although it is preferable that the assumptions regarding these component parts be made explicitly. The symbol ø signifies that this has been done in the case of any particular study. It will be seen that in the majority of instances such explicit consideration of factors has been disregarded.

The Greater Manchester and London studies, in essence, developed trend forecasts in vehicle registrations. The West Yorkshire and Merseyside studies on the other hand gave careful consideration to the growth in GDP, to modal competition, and to increases in average vehicle loads but ignored one important dimension of output, mileage, in deriving their control totals. These latter totals were expressed as trips per capita. The Belfast study used industrial production as the key demand variable and took account of "increased efficiency in utilization" of truck capacity in arriving at the growth in registrations.

With regard to the division of the vehicle stock between different size categories, the West Midland, Belfast, and Manchester studies decided on this division after the basic forecast. The West Midland study, for example, assumed a constant proportion of light pickup trucks, whereas the Belfast study took into account recent trends in the composition of the vehicle stock.

We must conclude that for the most part the study forecasts were of a rudimentary nature and ignored many of the important factors involved in the overall situation.

In spite of the vital importance of the control totals in the general freight model, there has been no attempt to consider whether the final outputs from this model have been consistent with the assumptions, implicitly or explicitly, included in the separate forecast of the control. For the most part this is understandable; the output characteristics are generally not in a form that would permit such checking. There is, however, one possible exception. This depends on the forecast of the control being based on an explicit assumption regarding the average length of haul or total truck mileages and on the distribution model providing an average trip length output. (In developing the "control" it is normal to assume that in the future the number of trips per truck will remain the same as at the present time. Because of this, total truck mileages can readily be converted to average trip lengths.) In these circumstances it is possible to check whether the average increase in trip length from the distribution model is consistent with that assumed in forecasting the control totals. Thus, we might envisage a model restructured as shown in Figure 1 with the overall model being recycled until a satisfactory consistency is achieved.

## ZONAL FORECASTS

We have already touched on some of the features and weaknesses of the typical trip end model used to develop the zonal forecasts. The typical trip end model includes, as independent variables, factors such as employment, resident population, and retail sales, perhaps stratified for different industrial or commercial groups. It has already been pointed out that these factors are essentially land use variables and that they are of limited use for examining different traffic and transport policies that have implications for the movement of freight.

Nevertheless, even in the more restricted context of explaining the effect of land use change on freight movements, the model often has serious weaknesses. The general procedure adopted has been based on the use of zonal aggregates with each traffic zone treated as one observation. Oi and Shuldiner (9) and Douglas and Lewis (10), among

**Table 5. Estimates of total future numbers (in millions) of heavy trucks.**

| | Annual Growth in Carrying Capacity | | | |
|---|---|---|---|---|
| Date | 1 Percent | None | +2.5 Percent | +5 Percent |
| 1970 | | 0.63 | 0.63 | 0.63 |
| 1975 | 0.78 | 0.73 | 0.64 | 0.56 |
| 1980 | 0.99 | 0.88 | 0.67 | 0.51 |
| 1985 | 1.25 | 1.05 | 0.70 | 0.47 |
| 1990 | 1.56 | 1.26 | 0.73 | 0.44 |
| 1995 | 1.99 | 1.49 | 0.76 | 0.40 |
| 2000 | 2.49 | 1.76 | 0.78 | 0.37 |

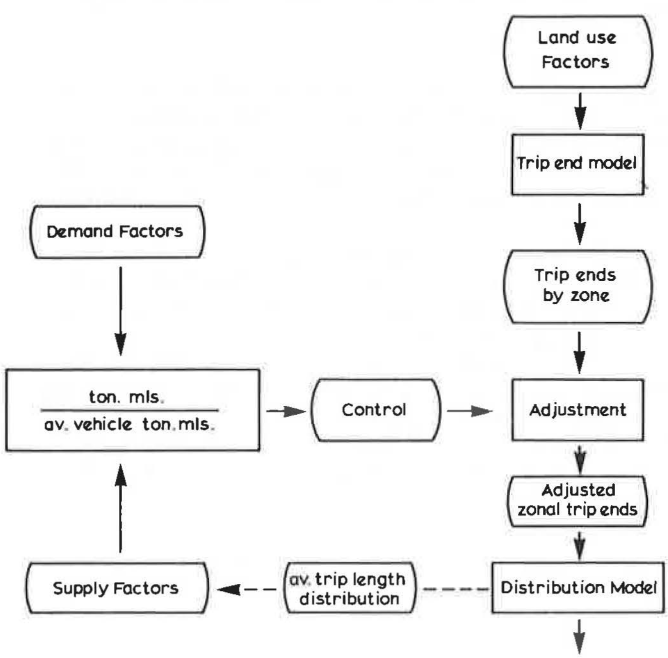
Note: The following assumptions are made: A linear relationship exists between GDP and total inland freight and GDP grows 3 percent per annum, and ton-miles by rail are constant.

**Table 6. Control totals developed in selected U.K. transportation studies.**

| Study (1) | Truck Type[a] (2) | Influence of GDP on Tons (3) | Influence of GDP on Ton-Miles (4) | Rail Competition (5) | Δ Avg Carrying Capacity per Vehicle (6) | Δ Loads or Load Factors (7) | Δ Miles per Vehicle or Avg Length of Haul (8) | Δ Ton-Miles per Vehicle (9) |
|---|---|---|---|---|---|---|---|---|
| W. Yorks (1957-68)[b] | HCV | ϕ | | ϕ constant percentage | | ϕ | | |
| | LCV | ϕ | | ϕ constant percentage | | ϕ | | |
| Merseyside (1966-69) | HCV | ϕ | | ϕ constant percentage | | ϕ | | |
| | LCV | ϕ | | ϕ constant percentage | | ϕ | | |
| W. Midlands (1964-68) | LCV, HCV | | ϕ | | ϕ | Constant | ϕ | ϕ |
| London (1962-68) | LCV, MCV | | | Trend forecast in registration | | | | |
| | HC | | ϕ | Adjusted trend forecast in registrations | | | | Constant |
| Belfast (1965-69) | LC, MCV, HCV | ϕ | | N.R.[c] | ϕ | ϕ | ϕ | |
| Greater Manchester (1965-71) | LCV, HCV | | | ϕ constant quantity | Trend forecast | | | |

[a]HCV = heavy commercial vehicle, ⩾1½ tons; MCV = medium commercial vehicle, ⩾3 tons; LCV = light commercial vehicle, <1½ tons, all unloaded weight.
[b]Approximate starting and completion dates.
[c]Rail competition not relevant.

**Figure 1. An iterative truck forecasting model.**



others, have pointed out the serious weaknesses of a grouped data approach in a forecasting context, and, as a consequence, person trip end analysis is now based on the household. This suggests that forecasts of truck activity at the zonal level should also be based on the unit of behavior, i.e., the firm or business organization. But prerequisite to such an approach is an ability to predict the necessary land use inputs, such as the number, type, and size of business units. Of course, at the present such an approach is not really possible.

Understandable though the use of grouped data might be at the present time, this does not absolve the transport planner from blame for poor statistical analysis, which is a characteristic of many studies. The main statistical failings involve the assumptions associated with the use of linear regression, the preferred statistical method in most studies. The chief assumptions are as follows.

1. The relationships should be linear. There is some evidence that this is not always so (11, 12).
2. Independent variables should be linearly independent of each other. The frequent practice of indiscriminantly putting all conceivable factors into a multiple regression suggests that this is unlikely to be the case. The outcome will be coefficients that, over a period of time, are unstable and therefore of little value for forecasting.
3. The variance should be homoscedastic or constant; i.e., the variation around the line of best fit must be independent of the observed values of each variable.

Recent models of person movement have avoided these stringent assumptions by using cross-classification analysis (referred to as category analysis in the United Kingdom). This is a superior method of averaging sample data over predetermined categories (or steps) in the relevant variables. But, unfortunately, as traditionally applied in the United Kingdom, the analysis produces no error terms in relation to the estimated coefficients (i.e., trip rates per category).

Therefore the use of cross-classification methods does depend on a confident specification of the causal variables and on a level of analysis that avoids the use of grouped data. Such methods are not recommended for application in their present form to freight movements where, generally speaking, these conditions are not fulfilled.

An alternative approach to these statistical problems is to use logarithmic (and other) transformations or dummy variables within the framework of regression analysis. For example, if properly applied, dummy variable analysis can give results similar to (or in the extreme case identical with) cross-classification methods and, in addition, provide the analyst with far more information on the accuracy of his model. The dummy variable method has been applied in freight movement studies by Starkie (13).

## CONCLUSION

Recent experience of forecasting urban truck trips in the United Kingdom has highlighted weaknesses of present methodologies in relation to a proper examination of policy variables. Nevertheless, progress is more likely to stem from an improvement in the fundamentals of the present approach. Ad hoc studies can and will provide useful information on the effect of different policies, but their methods will complement rather than supersede those currently in use.

Within the context of present methods, more care and attention should be given to forecasting the control totals in view of their key role in the overall prediction. Further improvement might follow from a disaggregation of the control totals for specified economic sectors and for different regions and subregions.

With regard to the forecast of truck trips on a zonal basis, U.K. studies will benefit greatly if more attention is given to the quality of their statistical analysis. In this context too, special studies, in this case of freight movements to and from industrial plants, can usefully guide and supplement the basic approach. At the present time they are unlikely to provide the basis for a new forecasting methodology.

## REFERENCES

1. Sharp, C. Living With the Lorry: A Study of Goods Vehicles in the Environment. Freight Transport Assn., London, 1973.

2. Chisholm, M., and O'Sullivan, P. Freight Flows and Spatial Aspects of the British Economy. Cambridge Univ. Press, 1973.
3. Hall, R. The Transport Needs of Great Britain in the Next Twenty Years. Her Majesty's Stationery Office, London, 1963.
4. Ministry of Transport. The Transport of Freight. Her Majesty's Stationery Office, London, Cmnd 3470, 1967.
5. W. Beckerman and Associates. The British Economy in 1975. Cambridge Univ. Press, 1965.
6. Chisholm, M. Forecasting the Generation of Freight Traffic in Great Britain. In Regional Forecasting, Butterworth, 1971.
7. Tulpule, A. H. Trends in Transport of Freight in Great Britain. Road Research Laboratory, Crowthorne, Berkshire, RRL Rept. LR 429, 1972.
8. Harrison, A. J. Some Notes on Road Transport Costs. Oxford Institute of Economics and Statistics, Bulletin, 1965.
9. Oi, W., and Shuldiner, P. Analysis of Urban Travel Demands. Northwestern Univ. Press, Evanston, Ill., 1962.
10. Douglas, A., and Lewis, R. Trip Generation Techniques. Printerhall, London, 1971.
11. Starkie, D. N. M. Traffic and Industry. Weidenfeld and Nicolson Ltd., London, 1969.
12. Saunders, L. Goods Vehicle Model Development—Some Results and Observations Relating to the Trip Generation and Distribution Stages. Proc., 1973 Urban Traffic Models Symposium, Planning and Transport Research and Computation Co. Ltd., London.
13. Starkie, D. N. M. The Treatment of Curvi-Linearities in the Calibration of Trip-End Models. Proc., 1970 Urban Traffic Models Symposium, Planning and Transport Research and Computation Co. Ltd., London.