panel report

DEMAND FORECASTING AND DEVELOPMENT OF FRAMEWORK FOR ANALYSIS OF URBAN COMMODITY FLOW

Alexander French and Peter Watson, chairmen

The task of this workshop was to look at the possibility of forecasting demand for urban goods movement, outline an analytical framework, and suggest a series of studies. The efforts of the group resulted in the following 6 proposals:

1. Undertake resource allocation study of alternate levels of analytical resources to guide a research program likely to have high payoff to the urban planner, administrator, and other officials;
2. Make a comparative analysis of previous studies and available data that would be useful and provide a starting point for item 1;
3. Investigate, develop, and test methods of measurement now used or proposed for urban goods movement to identify the fundamental characteristics that are basic and can be summarized to other classifications (an example of one method of obtaining detailed information is given in Lieder's paper in this Special Report);
4. Review ongoing activities, such as the transportation census, at an early date to identify areas where modifications in procedures could prove useful for urban goods movement analysis;
5. Test, modify, and refine the general framework for the analysis and forecasting of urban goods movement that has been outlined; and
6. Review and undertake specific study projects that have been developed.

The first 4 proposals are believed to be almost obvious and essential first steps and require little discussion. It was felt that before embarking on any serious study of this problem, it was first essential to establish that a problem does exist and that resources devoted to its study would be well spent. To this end, it was suggested that a feasibility study be carried out to investigate the possible outputs of studies of urban goods movement and the uses that could be made of such outputs. One suggested starting point is a comparative analysis of the work that has already been carried out on urban goods movement. That a great deal of work has already been done is beyond question, but the diverse nature of the work and its location in a number of places ranging from professional and academic journals to trade journals make its assessment somewhat difficult. It is felt that a literature survey culminating in a critical assessment of the work already undertaken and the production of an annotated bibliography are certain to be of priority importance in this field. There are a great number of units, such as consignments, ton-miles, truck loads, and dollars, that are used to quantify goods movement. These should be reviewed in relation to data collection techniques and analytical uses to determine efficient fundamental data items and collection procedures. It is further suggested that some investigation be made of the activities of the U.S. Bureau of the Census. It is known that the bureau is involved in some data collection activities involving the movement of goods, and it is thought essential that such activity be coordinated with other government-sponsored activities investigating the movement of goods.

The analytical framework and the list of specific projects are more complex and will be treated in detail.

STUDY FRAMEWORK AND MODELING

Any discussion of demand forecasting inevitably leads to a discussion of modeling, and the output of this workshop is no exception. The building of the model or model system, however, is not a simple matter. The selection of the relationships to be modeled and the form of the models themselves depend to some considerable extent on the use to which they will be put and on the requirements of the organization that commissions them. The discussion that follows will, therefore, be couched in general terms in the hope that the model framework suggested will be sufficiently general so that it can be modified to take account of the needs of various commissioning organizations.

It is appropriate at this point to make a few comments on the types of models that may be built. It is possible to build micromodels or macromodels. A micromodel is concerned with explaining the relationships involved in the movements associated with one commodity or one building. In other words, a micromodel concerns itself with all the demand characteristics of, for example, television sets or with all the demand characteristics of an office building. A macromodel, on the other hand, concerns itself with the larger picture. It attempts to model the movements of all goods among all locations—industrial, residential, and commercial—within the urban area. It is felt that the study of the movements of goods in urban areas requires macromodels.

It is also possible to build short-run or long-run models. The building of a short-run model implies that we expect relationships to remain constant or change very little in the near future. Thus, it is only necessary to make predictions of the dependent variables in the model in order to predict the level of demand. In contrast, a long-run model renders the assumption of a constant relationship unattainable, and the building of a long-run model implies that we are interested in trying to forecast changes in the relationships that we are modeling. Although this is an interesting research topic, it is felt that the present emphasis should be on short-run modeling.

Finally, it is possible to build sequential or parallel modeling systems. A sequential modeling system means that the inputs to one model are the outputs of the previous model and that there is no interaction between other elements of the model system. For example, the standard urban transportation planning package assumes that trip distribution, generation, modal choice, and network assignment models operate sequentially and that the mode-choice decision is quite distinct from the trip-generation decision. A parallel model system would be designed in such a way that all the relationships in the system could be estimated simultaneously by the use of mathematical programming or other similar techniques.

It seems logical in an attempt to develop a model framework for goods movement to start with the framework for the analysis of people movement that already exists. Therefore, a discussion of the models used to forecast demand for passenger movement follows. A typical urban transportation planning package begins with a model to generate traffic from the various zones into which the area is divided. It does this by relating the number of trips observed to originate in a given zone with the characteristics of that zone. The characteristics may include income levels and land use. The model system proceeds to distribute these generated trips among the zones that compete as destinations. This is done by using a gravity type of model or an opportunity type of model. In concept, the characteristics of the zone are related in some way to the number of trips that have their destinations within those zones.

In terms of a model system to model demand for the movement of goods, this means taking the trip-generating and trip-attracting characteristics of the various units within the system, i.e., factories, offices, and residences, and generating from them the trips or shipments that would be made among the various units. The level of service desired by the system is established, and then these needs are allocated over the physical network. In the people-movement case, this is done by 2 models. The first of these assigns the desired level of trips between the different modes of transport available, and the second assigns those trips being made by automobile over the alternative native routes through the road network. Although the trip-generation and trip-distribution models seem readily convertible for the analysis of goods movement, the modal choice seems less applicable. As has been heard before, most of the goods movement problems in urban areas are associated with trucks. This leads us to try to redefine a mode in such a way that the definition will not simply indicate the mode used, whether rail or truck or pipeline, but also indicate some of the characteristics of the service. For example, it may be possible to subclassify the truck mode into a number of alternatives, such as a truck carrying ready-mixed concrete, a truck carrying washing machines, or a small van carrying parcels. In order to distinguish the reclassified modes, the term "means" was coined.

Clearly, the problem of classifying the trucking mode into means is tied up with the problem of measuring urban goods movement. The question of units has previously been raised, but it is sufficient at this point to mention simply that it is still undecided whether goods movement should be measured in terms of ton-miles, consignments, weight, value, some combination of these, or some other measure. Having established the distribution of the goods between the various means available, we must allocate the movements thus obtained over the physical road network. A number of sophisticated computer techniques are available for doing this, but it is felt that they are likely to require modification because they tend to operate on the basis of finding minimal costs or minimal time routes through a network between 2 points. The fact that goods movement often involves multiple destinations, i. e., delivery trips, it is possible that the network assignment model will have to be modified. It is also likely that an interference model will be required to reflect the extent to which flows by one means influence the characteristics of flows by other means. For example, if parcel trucks and dump trucks are traveling on the same road, an increase in the number of dump trucks will adversely affect the operating characteristics of the parcel truck. Operations will slow down; waiting time, opportunities for collision, pilferage, and costs will increase. It is, therefore, necessary to build into the model some reflection of the way in which one movement will interfere with other movements.

Clearly, in order for such a model system to be useful to operators, their needs have to be built in. First of all, it is necessary for the system to output the costs of moving goods by different means and over different routes through the network. Second, it is necessary to build in some constraints based on the preferences of the shippers. The question of time reliability may be important for some goods, particularly for perishable goods because they must be delivered before a certain time. For other goods, arrival ahead of time may involve additional warehousing costs and be equally undesirable. Some shipment may be vulnerable to damage or loss; other shipments may not.

So far, the discussion has dwelt on possible comparison between people and goods movement and has introduced some of the features that a demand modeling system include. It is felt that the framework for analysis that follows includes the good features of the people-moving analysis system but is extended to cover some elements omitted by the people-moving analysis system and also to take particular account of some factors important to goods movement. This model framework was suggested by a proposal presented in this Special Report by Goeller. Figure 1 shows the conceptual framework for analysis, modeling, and forecasting.

Some urban transportation planning analysis procedures have been criticized for failing to take account of the effects of travelers' location decisions on their travel behavior. Because location decisions related to goods movement often involve explicit consideration of transportation characteristics, this framework begins with the location of industry. The first model in the system explains why industries locate in certain places. Such a model may relate industrial location to factors such as rents in various places, taxes, availability of labor, and costs of transportation.

After the location of industry is examined, the second step is to investigate the interindustry transactions. This involves examining the operations of each industry in order to see what kinds of demands it creates for goods and what kinds of products are produced. In other words, the model will tell us, if given the locations and types of

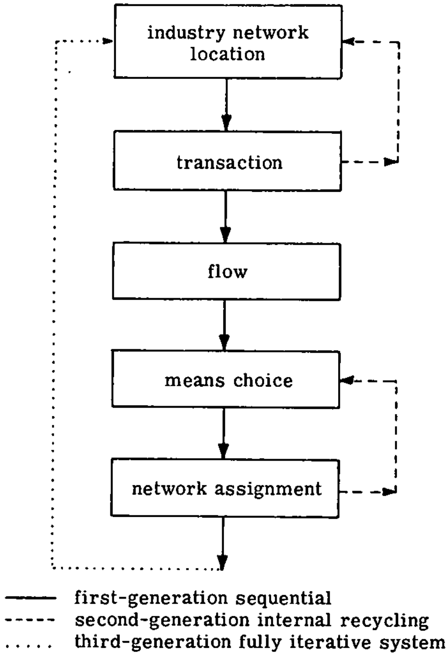

Figure 1. Conceptual framework for analysis, modeling, and forecasting urban goods movement.

industries, what output they will produce and what demand they will have from other industries. It should be noted at this point that the term "industrial location" is sufficiently wide to include the location of residential and commercial units. The first 2 models will indicate why different activities locate at different places and what demands they create and what outputs they produce.

The third model in the system is a flow model that will explain how the outputs of the producing units and the consumption of all units will be coordinated. Thus, if given knowledge of the production and consumption desires of the various activities, the flow model will show the flow of goods over the system that would be necessary to coordinate the production and consumption.

The fourth model in the system will allocate these flows to the different means as defined earlier. It is felt that the model that will do this will have conceptual similarities to the modal-choice model for person travel that is used in the urban transportation planning package.

Finally, when it is known what the flows will be and how they will be distributed over the means in the system, it is necessary to assign these movements to the network. Again a similarity to urban planning procedures is evident.

The framework that has been described in general terms is set up as a 5-model sequential system and is, as described, extremely general. It has, however, a number of properties that make it useful for the problem under consideration. As described, the model system is sequential, but it is thought that mathematical programming techniques can be used to convert the sequential system of models into a simultaneous system of models, thus making interactions among the models possible.

Also, the model is set up in 5 steps, but it is thought that some of these steps can be collapsed. In particular, it is possible to collapse the transactions and the flow models in order to produce a single model that generates the interunit flows from a knowledge of the production consumption properties of those units. It is also thought that it may be feasible to collapse the mean choice and network assignment models in order to allocate simultaneously to means and the physical network. Another interesting property is that the system can be recycled and solved by an iterative process. Having started with the location of industry, one can work through the system generating flows and allocate them over the network. It is then possible to investigate the way in which the level of flows generated by the models on the network affect the location of industry. Should the location of industry be changed, the flows from the new locations can be generated and reassigned over the network. It is thought that this iterative property will be most useful.

The final property of interest is that it is not necessary to work through the complete modeling system. It is possible to omit the industrial location model and, if there are fixed industrial locations, to look at the levels of demand in terms of flows desired between units. It is also possible to leave out the industrial transactions model and, by taking the consumption and production flows as given, to calculate the flows necessary to optimize the system. It is even possible to dissect the last stage of the modeling system and to look simply at the problem of the efficiency of routing through the network. Given movements by specific means, one can consider simply how to move them most efficiently through the network. It is thought that this final property is most important. The panel feels that it is not necessary to find a once-and-for-all solution to the whole problem of urban goods movement. Different people can move in at different points and tackle different aspects of the problem. It is unlikely that the whole problem will be solved all at once, but it is thought that the modeling framework described is sufficiently flexible to allow progress to be made in small steps.

Having set up a framework for analysis of urban goods movement, one must specify the levels of activity at which it can be used. It is felt that there are essentially 2 levels at which this problem can be tackled. The first level has been called the "quick-and-dirty" model. It is clear that planners need results, not in 10 or 15 years but now, and it is essential that a model system, however crude, be evolved relatively quickly. In order to ensure development beyond the quick-and-dirty stage, a theoretical approach to the problem has been suggested. It is suggested that economists be put to work looking at the problems of industrial location and interindustry transactions and that computer specialists and mathematicians be set to work on problems of network assignment. In short, let some theoretical work be done on the problems with which we are dealing so that 10 years from now we are not still operating with the quick-and-dirty model and pretending that it is justifiable. It is necessary to use experience with the quick-and-dirty model in conjunction with the proposed theoretical work in order to develop a second-generation model and possibly a third-generation model so that the modeling procedure continues to improve and the information given to planners and other consumers of demand data are as good as possible.

PROJECTS AND STUDIES

A number of goals have been suggested for an urban goods movement study. One that seems generally accepted is stated in general terms such as ". . . improvements in the efficiency of activities as related to urban goods movement." There appear to be a number of objectives to be achieved on the way to this goal, many of which have not yet been recognized nor agreed on. On the other hand, there are well-identified strategies and tactics available for achieving the goals and objectives of an urban community. To sharpen the focus of some of the proposed projects it seems worthwhile to discuss these as they relate to the various elements of the analysis framework. These relationships are as follows:

Analysis Framework Element	Strategy and Tactics Available to Government
Location	Zoning Taxation of land Fees for and accessibility to services
Transactions	Antitrust laws Taxation of sales, inventory, and income Licensing and franchising
Flow	Licensing and franchising Policing Traffic operation
Means	Licensing and franchising Zoning and building codes
Network	Capital improvement Policing and parking regulation Zoning and building codes
All	Research and analysis Education and dissemination of information Funding

Because these strategies are in operation every day, the various elements of goods movement activities are evidently being modified to some degree. Thus, it is suggested that, in pursuing the projects discussed subsequently, attention be directed in the analysis to the elements that are sensitive to these and other identifiable strategies and tactics available to government.

Let us turn to research projects for an attack on these problems. The following projects are discussed in order of increasing complexity, and those listed first are studies through which a candidate for a master's or a doctoral degree might make a substantial contribution: (a) a study of a single commodity or commodity category in an urbanized area; (b) a study of an activity center, a single office building, or a single industrial park that is small enough in scale to be understood, measured, and analyzed and that involves different goods movements that can be traced and described; (c) a study of prototypical cities at a scale that can be analyzed comprehensively at a minimum cost and in which techniques can be tested quickly and economically; (d) examination of the goods-persons movement dichotomy to determine what the problems really are in using subways for moving solid waste or making certain deliveries, at night or other off-peak periods; and (e) development of a demonstration project to test the feasibility and effectiveness of various alternative shipment consolidation and clustering procedures including the procedures described in this Special Report by Wood to minimize vehicle-miles per ton delivered and achieve other efficiencies. Different prototypical cities referred to in (c) can be readily compared. Albuquerque, New Mexico, Sioux Falls, South Dakota, and Hagerstown, Maryland, have previously served in this role for other purposes and may provide extensive related data at minimum cost. It must be remembered that each city is unique, so that study of prototypical cities will help to develop techniques. Substantive relationships observed in 2 or 3 small cities are not expected to be applicable to other cities because of differences in industry mix, geographic orientation, and other variables.

EVALUATIONS AND OTHER STRATEGIES

There are important problems that cannot be specifically incorporated into a modeling system because they cannot be satisfactorily scaled. These are described as evaluations and are discussed in the following.

Environment impacts of various kinds have been mentioned. In addition to amounts of air pollution and noise, there are other annoying effects that are little understood; all of these must be identified, classified, and evaluated.

There are measurable impacts that would be relatively difficult to measure and feed into a model. In many cases a great number of measurable variables can be identified as "significant" in the statistical sense, but it is extremely difficult to devise a model that is realistically sensitive to more than 5 or 6 variables. Under particular conditions certain of these additional significant variables may be critical to a particular decision. These should be identified and evaluated subjectively.

If the cost-effectiveness study shows that extensive detailed urban goods-movement analysis is worthwhile, then a curriculum unit in the subject would be worthwhile. This curriculum unit would be designed to be adaptable to many types of undergraduate and graduate courses in business administration, transportation economics, planning, civil or industrial engineering, and other suitable fields.

The benefits and costs of staggered hours as related to urban goods movements should be investigated. From the discussion in this Special Report by Foreman and Weiss, there are costs and benefits to urban goods movement resulting from staggered hours, night delivery, and other scheduling adjustments. These procedures should be studied.

Finally, there is no point in developing modeling and analysis procedures if they are not useful in identifying and guiding desirable policy changes. As the discussions and findings of this conference are circulated and as some of the proposed studies are completed, goals can be identified and the need for policy change determined. Candidate policy changes should be identified promptly to provide helpful definitions and targets for other study efforts.

CONCLUSIONS

It is probably safe to say that this panel agreed that, in view of the resources currently involved in providing urban goods movement, an effort to obtain a better understanding of the costs and interrelationships is worthwhile. At the same time it was considered important to avoid the temptation to develop either overly simple or excessively complex procedures that do not provide useful solutions to the day-to-day problems facing urban planners and administrators. These include zoning, parking regulations, tax rates, and capital improvements. A number of study activities have been suggested for consideration. Only the first four—analysis of study payoffs, comparative analysis of previous studies, methods of measurement, and review of ongoing census activities—are recommended without qualification. It is noteworthy that analysis of study payoffs is listed first. This reflects the concern for efficient use of limited urban transportation analysis and planning resources in the face of rapidly increasing demands for these resources. In addition, a modeling framework has been suggested to help guide analysis of immediate problems toward a long-range forecasting capability.