c.1

A MARKETING MODEL OF TRANSPORTATION DEMAND AT INDUSTRIAL SITES

BY

IAN N. DAWSON

M.A. UNIVERSITY OF GEORGIA, 1968

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in the Department of Geography

We accept this thesis as conforming to the required standard:

THE UNIVERSITY OF BRITISH COLUMBIA

October 1973

Department of Geography

The University of British Columbia
Vancouver 8, Canada

Date 19th March 1974

A MARKETING MODEL OF TRANSPORTATION DEMAND AT INDUSTRIAL SITES

BY

IAN N. DAWSON

ABSTRACT

This study analyses the factors which influence the volume of truck movement from urban manufacturing sites. The significance of these factors is tested by means of a case study of forty-three wood products plants in Vancouver, British Columbia.

Some of the dangers of applying the assumptions of urban passenger travel analysis to urban goods movement studies are discussed, with emphasis on the problems of aggregation and forecasting. A review of urban goods movement studies to date shows that previous research does not incorporate explanations of the causal mechanism behind variations in truck transport demand, but rather relies on simple within-site variables such as employment size to estimate the volume of trip-making.

A marketing model is proposed. It takes the form of least-squares multiple regression equations which add marketing variables to the basic plant-size model. The development of the theory behind the marketing model discusses the expected influence of the manufacturer's physical distribution channel on

his trip generation rate. Characteristics of the channel which are expected to be significant are the behaviour of customers for the product with respect to shipment size, transport supply, and their own function in the distribution channel.

The effects of marketing variables are tested using data gathered by a personal survey of truck movements over a period of one month from wood products manufacturers. A significant improvement in the explanatory power of the marketing model over the plant-size model was revealed when the proportion of the manufacturer's market which is retail-oriented in taken into account.

The same survey data was used to estimate retailers' trip attraction rates. Size of their supply-market and truck capacity were found to be significant. Lastly, the future conditions which may limit applications of the model are discussed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

The following are acknowledged for their assistance in the completion of this thesis:

Dr. Walter Hardwick, for his guidance, encouragement and insight.

Dr. J. D. Chapman, Dr. R. L. Leigh, and Dr. T. Heaver for their continual support and constructive criticism.

Wood products manufacturers in the Vancouver area for the provision of confidential data.

The Canadian Transport Commission for its financial support.

Harry and Julie Swain, for labouring over the illustrations during an Ottawa summer.

Pat Coughlin and Karen Klein for typing the manuscript.

CHAPTER 1

INTRODUCTION

Context and Purpose of the Study

The subject of this research is the movement of commercial vehicles in urban areas. In particular, the study describes and tests the causal influence of several factors on the volume of truck trips generated at industrial sites. The most significant advances in urban transportation analysis during recent years have been made with respect to persons movement, with little progress on the side of commercial vehicle and urban freight movement explanation or forecasting. This study is a partial redress of this imbalance. It explains why the volume of transportation demand at manufacturing and retail sites is a response not only to the internal characteristics of the site, such as its size, but also to the nature of its external linkages, i.e. its supply and market areas.

There are fundamental reasons for improving our understanding of the nature of commercial vehicle and commodity flows in urban areas. One reason is to lend support to that school of thought which views the city as a complex but nevertheless understandable system of interrelated activities. The basic assumption of urban transportation research is that the city is a system of inter-related activities. These activities are the system components, and they are described in such terms as their volume, density, and distribution. They may also be described in terms of their dynamic behaviour, which may be responsive or goal-seeking, or some combination of the two. Urban transportation research is concerned with patterns and intensities of movement which functionally associate activities with each other through space. An understanding of these linkages between activities (or land uses, to give them a spatial dimension) is a prerequisite to the explanation and prediction of the city's characteristics and its behaviour as a system. This is the contribution of urban transportation research to urban geography. There is no need to attempt a definition of the scope of urban geography to defend this assertion; a cursory glance at recent general treatments of the subject indicates its importance.[1] However, in transportation research generally it is the theoretical and empirical analysis of passenger movement which has contributed most towards our understanding of the present structure and behaviour of urban areas. This, despite the fact that the movement of freight is known to be a significant determinant

---

[1]Indeed "definitions of scope" are probably outmoded; see Berry, B. J. L. and F. E. Horton, (ed.) <u>Geographic Perspections on Urban Systems</u>, (Englewood Cliffs, N.J.: Prentice Hall, 1970), and L. S. Bourne, <u>Internal Structure of the City</u>, (London: Oxford University Press, 1971), for an indication of the scope of urban geography.

of many commercial and industrial locations.

The second reason for needing research into urban commercial vehicle and commodity flows is to improve our ability to plan the urban physical plant. Planning in urban areas is required to achieve distributional effectiveness; that is to achieve a balance of income distribution which is somehow generally desired. There are many states of distributional efficiency, and the most common general planning goal is to encourage that state which maximizes distributional equity, constrained by efficiency criteria. That is to say, in the context of this thesis, before planning power is brought to bear on the locational and operating rules governing the behaviour and existence of firms, we require a substantial amount of information about their requirements - land, labour, access to markets and materials. Otherwise we run the risk of achieving distributional equity, which for example might entail all polluting firms being located distant from the city, without knowing either the sacrifice to efficiency or whether the goal (reduce pollution) had been achieved the most effective way.

Planning is also required to correct market failures which may result from either the indivisibility of a good or from externalities. The latter is especially important for the public sector, whose responsibility it is to redistribute the impact of externalities. It may be that commercial vehicles do not fully pay for the congestion, noise and air pollution and general inconvenience they cause on city streets. This contention, if it were hypothesized, would probably be rejected, but how then do we reduce the impact of truck transport on urban areas? By restricting trip-making; by re-arranging land uses? This brings us back to the need to know which activities require how much transportation, and for what reason.

Of the three major components of the planning process - analysis, design, and policy-making - this thesis is concerned only with the first. Urban geographers and planners part company at the design stage but their interests in analysis are partly coincident. It is the question of analysis, its assumptions and methods to which we now turn.

The Approach and Method for this Study

Linkages between otherwise distinct urban activities are important for the urban geographer and planner. Chapin adds clarity to the notions of "system component" and "linkage" through his definitions of activity and movement systems.[2] An activity system comprises the "behaviour patterns of individuals, families, institutions, and firms which occur in spatial patterns". Examples of activity systems relevant to this thesis are those endeavours which produce, transport, trade, consume commodities in cities. "Transport" is something of a special case - Chapin uses the term "movement system" - for it

---

[2]Chapin, F. S. Urban Land Use Planning, (Urbana, Illinois: University of Illinois Press, 1965) Chapters 6 and 8.

aids the physical circulation of commodities both within and between activity systems. We may detect systems-within-systems constrained only the the logic of defining micro-systems of activity, computational and institutional resources, and research objectives.

The activity site is normally the logical unit of analysis, although to facilitate computation and to satisfy many planning needs, sites may be grouped into zones. Zonal aggregation, however, poses problems which will be reviewed in Chapter II. For now it is sufficient to observe that transportation patterns are spatial manifestations of linkages between activity sites, and that transportation trip generation rates per unit time are measures of the intensity of these linkages. Explanations of trip generation rates and trip patterns are essential to the planning of fixed transportation facilities and public investment in vehicles; there is also some evidence that such explanations may contribute to our knowledge of the factors influencing activity site location. These questions of aggregation, trip generation rates and patterns, and relevance to planning and location all influence the methodology used, hypotheses tested, and the significance and usefulness of research results.

It is a fundamental assumption of the class of research to which this thesis belongs that the city as a system is made up of components whose interrelationships may be modelled. This is based on the belief that within the complexity of the urban area there is an underlying order, a quantifiable logic, whose structure, behaviour, and response to stimuli must be abstracted as an essential prerequisite to understanding, explaining, and forecasting urban phenomena. This is the rationale for the use of models.

It is not the intention of this study to construct a model of urban truck transportation which is comparable in terms of complexity and success to those available in passenger transport. The reason for this is that the theory behind the model is almost non-existent. A model is a representation of a theory, which in turn is a set of relationships known or hypothesized to exist between the theory's subject and its environment. The structure of the model should therefore parallel that of the theory. Social science theory is far weaker than the modelling tools available; as a result, most urban research tacitly accepts the weakness of theory and concentrates on the modelling problem. Thus we have available a large body of literature and research results on questions of model calibration (variable definition and parameter fitting) and model testing, but less on the behavioural foundations of the model which lead us, a priori, to expect one kind of relationship between model (or system) components rather than another. Consequently, this study focuses on the probable foundationsof a theory of urban truck transport, rather than model calibration and testing problems.

Two distinct approaches are available by which to analyze the city as a system. First, the dynamic approach examines the forces acting on the system as a whole. Such forces may be policies or processes which stimulate changes in system behaviour: urbanization, changes in the distribution of income, shifting societal values, or changing economic activity and technology. However, dynamic models of system behaviour rely upon a clear understanding of or at least defensible assumptions about the nature of relationships among internal system components. It is not surprising therefore, that dynamic models of urban areas are a recent phenomena and have only tentatively been tested.

The second option may be termed the <u>behavioural</u> approach. As suggested above, it is a prerequisite to the building of dynamic models since it is concerned with the micro-relationships between different urban activity systems. This approach relies heavily on theories about choice of location, volume of services or commodities demanded at a price, changes in supply given a change in demand, and vice versa. It is <u>partial</u>, in the sense that only a finite set of relationships are modelled - those which can be related in an assumed and immediate causal way to the subject of the model. For example, number of automobile trips per household might hypothesized to be a function of household size and family disposable income. The approach is <u>static</u>; the model is calibrated on data which refer to one specific point in time. Its forecasting ability is limited by the degree to which we can attribute causality to relationships specified in the model, by our ability to estimate the independent variables and future values, and by the extent to which the environment (other urban, "un-modelled") relationships remain constant.

Most urban research which uses models and theoretical constructs relies on behavioural approaches which do not incorporate feedback mechanisms characteristic of dynamic simulation models. The reason for this is to be found in the complexity of the system and the linkages between activities and the importance of intangibles such as values, needs, and opportunities in human activity. Despite the essentially static nature of a behavioural approach, and its inclusion of only partial relationships, it is of necessity the means selected in this study for the analysis of urban commodity flows. Out of building blocks such as these, we may one day hope to attempt complete simulation models.

Another major assumption of significance to the method of analysis is that which relates to transportation demand. We assume that the city is a productive entity consisting largely of households and firms which buy and sell goods and services in an open system, "open" in recognition of inter-city linkages. The major output of transportation in this system is a service which is consumed by households who either buy transportation services in combination with other goods...or directly to gain place utility for themselves" and by firms who "buy transport services as a factor of production.[3] In other words, the demand for transportation is a derived demand whose magnitude, in the case of firms at least, should be a function of the quantities of goods consumed. The spatial occurrence of this demand should be a response to the locations of the demand for and supply of those goods.

If the appropriate measure of transportation demand is ton-miles as it might be for location problems, then the problem is one involving "goods movement"; if, however, we wish to convert transportation demand into measures of significance for urban transportation system planning, an estimate of vehicle (truck) movement is required.

Organization and Major Findings

It is assumed in this thesis that some version of the traditional approach to urban transportation analysis will continue to be useful. This approach involves a multi-stage modelling procedure: trip generation, distribution, modal split and trip assignment to the transport network, although only the first stage - trip generation - is applied in this thesis to urban truck movements. In Chapter II, the two main drawbacks of this traditional procedure for analysis are presented; it involves problems with aggregating units of analysis in zones, and forecasting without a real understanding of the basic causes of trip-making behaviour. Justification

---

[3] Snell, J. and P. W. Shuldiner. Analysis of Urban Transportation Research. (Evanston, Ill.: The Transportation Center, Northwestern University, 1966), p. 10.

is made for studying the transportation behaviour of individual units of analysis, in this case the firm, and isolating the causal factors behind such behaviour.

Chapter III investigates previous analyses of truck trip generation rates. The studies selected for discussion are divided into two groups: conceptual models/proposed research strategies, and empirical studies/surveys. The first group, conceptual studies, supports the conclusions of Chapter II: that the distinct set of variables and constraints to which truck and freight movement responds must be identified. However, the empirical studies and surveys carried out to date have been either non-explanatory, in that no causal analysis of variable relationships has been attempted, or overly simplistic in that the variation in local transportation demand (truck trips) is attributed solely to within-site variables such as employment size.

Chapter IV is devoted to the development of a <u>marketing model of urban truck transportation</u>. The main premiss of this model is that the volume of commercial vehicle trips generated by a manufacturing site is a function not only of the size of that site, in terms of numbers of employees, but also characteristics of the market for the product (location, function, and size) and transportation supply (size of truck and type of ownership especially). In other words, the <u>physical distribution</u> environment of the firm is asserted to have significant implications for transportation demand.

Transportation demand's relationship with commodity demand is discussed, the possible influence of truck transport supply on truck trip demand is assessed, and industrial location theory is investigated for further insight into the behaviour of firms. However, it is concepts from industrial structure and physical distribution analysis which lead to the hypothesis that the physical distribution <u>channel</u> and firm behaviour within it could usefully explain variations in the volume of local commercial vehicle movement.

Adequate data to test this model were not previously available, and an in-depth survey of over 40 firms in the Vancouver area was conducted to produce such data. Chapter V explains the survey procedure and the definition of variables, while Chapter VI provides a test of the trip-generation model based on plant size variables. Chapter VII tests a second generation model, i.e. one which is modified by experience gained in testing the plant-size model and which introduces physical distribution variables. It is found that taking into account the proportion of the local market for the product which is shipped directly to retailers improves the explanation and estimation of trip generation rates.

The survey approach used to estimate trip generation rates releases a secondary benefit: data on the <u>trip attraction rates</u> of sites which constitute the local market of the manufacturer. Chapter VIII analyzes these trip attraction rates and relates them to transportation supply, specifically vehicle carrying capacity.

Chapter IX evaluates the conditions upon which the marketing model of trip generation and attraction rates is based, and assesses the implications for model limitations of changes in these conditions.

Chapter X draws generalized conclusions, identifies the significant gaps in our knowledge, and recommends priorities for further research.

The major finding of the analysis is that the introduction of marketing variables, specifically the type of distribution channel used locally (retailer, wholesaler, or re-manufacturer), does have a marked influence on the volume of truck trips generated by a manufacturing site. This effect is largely due to differences in consignment size, depending on the customer's activity, but it is also associated with variations in truck transport supply, notably the size of truck and its ownership.

The analysis of retailers' trip attraction rates leads to conclusions which at first might seem at odds with conventional wisdom. Local trip making does not decline with distance, but if anything appears to increase. This is attributed to the influence of truck capacity limits, and probably holds only for certain special cases, the Vancouver wood products trade being one of them. For the most intense linkages between pairs of retailer and manufacturer, truck capacity is the most important explanatory variable; it is positively associated with the number of trips. Where all linkages are considered however, including those which are weak, the number of suppliers to each retailer is the dominant explanatory variable.

Several of these variables and their effects have never been tested before, so the analysis, while applied only to one industry in one city, does serve to create new knowledge about the behavioural factors behind truck transport demand in local areas.

Lastly, the conditions under which the model will or will not hold when used for forecasting are evaluated. Although ten possible future conditions are postulated, special emphasis is placed on changes in the volume of local shipments, possible lags between the independent variable (shipments) and its predictor (production), and the changing structure of manufacturing and marketing. Naturally, it is only possible to assess the validity of the model in this way because the underlying causes of variation in truck transport demand have been identified initially.

CHAPTER II

DEFICIENCIES IN URBAN TRANSPORTATION PLANNING

Transportation Planning Methodology

The discussion which follows is with primary reference to persons' movement in cities. It is here that the most significant methodological and analytical advances have been made in transportation planning; weaknesses in this field, therefore, take on greater importance whenever goods movement is considered.

The classical method of "explaining" and forecasting urban transportation demand uses the following procedure:

(1) Trip generation: estimation of the number of trips into and out of traffic zones.

(2) Trip distribution: estimation of the number of trip interchanges between pairs of traffic zones.

(3) Modal split: determination of the means of travel by which people and goods move.

(4) Trip assignment: allocation of the output of (3) to the present or some future transportation network.[1]

---

[1]It is not suggested that this format is universally adhered to. It is presented as a norm to which variations and refinements may be added. A common variation is the combining of generation and distribution stages into one process, as in the use of gravity models.

Once stage (4) is complete, the following may be estimated: excess travel over link capacity, the impact of predicted activity sytem characteristics on transportation demand, or the impact of new transportation facilities.

This sequential process of transportation research and planning has been very widely documented and used. It is obviously extremely important for our cities that it be a rational and efficient method of guiding investment and policy decisions. Most of the attention has been directed towards trip distribution and modal split; these are certainly the most technically complex phases of transportation planning. However the accuracy of results is heavily dependent on the availability of good trip generation information. In stage (1), trip generation estimation, recognition is given to the relationship between travel behaviour and various measures describing land use. One of two techniques are normally used to describe this relationship:

(1) The linear least-squares model:

$$Y \quad a + b_1X_1 \ldots\ldots b_nX_n$$

where: Y trips generated from or attracted to traffic zones.

$X_1 \ldots\ldots X_n$ are explanatory variables which may be socio-economic, or measure location, density, relative accessibility to alternative modes, etc.

(2) Category analysis: this is essentially a non-parametric version of the least-squares model. It employs cross-classification techniques, was first developed

in the Puget Sound Study, and has found its greatest uses in the U.K.[2]

(3) A third technique which will undoubtedly see greater attention is simulation modelling. Putman discusses one proposed application to urban transportation planning which explicitly includes commodity movements.[3] Simulation models have a conceptual advantage over static models in that they are dynamic (time, or more accurately the behaviour of variables through time, is an essential component of the model's structure), and may be stochastic: i.e. the result of one run of the model is but one of an empirical probability distribution of results. The main advantages of simulation models are:

(a) They allow us to analyse causal chains in complex systems, and overcome some deficiencies of multiple regression techniques in observing the behaviour of systems through time.

(b) They are structured so as to allow for man-machine interaction, and thus perform useful learning-process functions.

---

[2]Walker, J. R. "Rank Classification: A Procedure for Determining Future Trip Ends," Highway Research Board, Record, 240, (1968).

[3]Putman, S. H. "An Integrated System of Modes for the Analysis of Urban Transport Interfaces," Transportation Journal, (Spring, 1971), 29-39.

(c) Simulation models, by containing feedback mechanisms which allow model outputs to be rerun as inputs, model the continuity of system behaviour.

The main problems in simulation models are their enormous data requirements, computational resource requirements, and (usually) the lack of firm theoretical bases on which to estimate the structure of system behaviour. Consequently, such models are, at the moment, in experimental stages - at least as far as urban socio-economic systems are concerned.

The development and testing of the first two model types has been almost exclusively in terms of persons' transportation demand; work on simulation models is only in its infancy. Where commercial vehicle trip generation rates have been estimated, the explanatory variables have been inconsistent from one study to another. This suggests that the reasons for their selection are based on apparent close association rather than any underlying causal structure. Table 1 demonstrates the wide range of variables which have been used in the past.

Furthermore, in their short summary of the relative merits of trip generation techniques applied to persons movement, Douglas and Lewis found that household-based models were improvements on aggregate (zonal) models:

> "...trip end models based on zones should be rejected. Such models have shown to be unstable from one area to another; hence, there is little reason for assuming they

TABLE 1

FACTORS USED TO ESTIMATE TRUCK TRIP ATTRACTIONS IN SELECTED CITIES

City - year	Variables
Washington, D.C. 1963	none
New Orleans, La. 1960	DU,D,E, A_c,SC
Kansas City, Mo. 1959	none
Ft. Worth, Tex. 1964	P,E_c,E_m, E_o
Charleston, W.Va. 1965	E_v,T,S_v,
Nashville, Tenn. 1961	none
Chattanooga, Tenn. 1962	none
Waterbury, Conn. 1963	P,E_c,E_m,
Erie, Pa. 1963	P,E_r,E_m,
Greensboro, N.C. 1964	P,E_c,E_m,
Fargo, N.D. 1965	C,E,E_r
Appleton, Wis. 1965	DU,E,A_c, A_i

Key to Variables

E = Total employment

E_r = Retail employment

E_m = Manufacturing employment

E_c = Commercial employment

E_o = Employment other than retail & mfg.

E_v = Various specialized employment

S_v = Retail sales by various specialized categories

A_i = Acres of industrial land

A_c = Acres of Commercial Land

SC= Total school enrollment

P = Population

DU= Number of Dwelling Units

I = Income

C = Number of automobiles

D = Distance from CBD

T = Truck ownership

Source: Shuldiner, P.Q. "Land Use, Activity, and Non-Residential Trip Generation," Highway Research Board, Record, 141 (1966), p. 12.

> will be stable over time...Future work should concentrate on the development of household models, in order that all the important parameters affecting trip generation can be isolated."

The authors also favoured the retention of least-squares regression analysis as a means towards developing such models.[4]

The question being raised here is a fundamental one: are present methods of trip generation analysis moving towards an axiomatic formulation of the subject's contents? There is increasing evidence that they are not.[5] One of the most serious allegations against most transportation studies is that trip generation models relating transport average variables may or may not describe a functional relationship which exists in reality:

> "...to date in the area of forecasting traffic movements, the emphasis has been on what people do, with relatively little attention devoted to why they choose to

---

[4]Douglas, A.A. and R.J. Lewis. "Trip Generation Techniques", Traffic Engineering and Control, (November 1970 to February 1971).

[5]"The axiomatic method consists of formulating a set of propositions which must fulfill certain conditions. They must be free of contradictions, and the deductions derived from them must contain our knowledge of the field and ....hopefully, lead to insights". O. Morgenstern, "Limits of the Uses of Mathematics in Economics," Mathematics and the Social Sciences, ed. J. C. Charlesworth (Philadelphia: The American Academy of Political and Social Science, 1963), p. 23.

> do what they do. A traffic projection based on how people have behaved in the past implicitly assumes people will behave on the average the same way in the future....Intuitively we know that man's behaviour is constantly changing in response to his social system."[6]

If, in the above lines, we substitute "firms" for "people" and "economic" for "social" we have a statement of the problem towards which this thesis is directed. Recent research in the field of passenger transportation has emphasized the internal characteristics of households and individual behaviour. This line of research has relied strongly on disciplines outside urban geography and planning, mainly consumer behaviour theory, social psychology and attitude studies.[7]

Before summarizing the previous research of particular relevance to the goods movement model presented later, there are two particular methodological problems which should be briefly introduced now: forecasting and level of aggregation. They are consequent upon the above discussion and have implications for the approach taken in the subsequent modeling process.

Forecasting

The purpose of modeling transportation demand in cities is to abstract reality so that we can study its most

---

[6] Chaplin, F. S., loc. cit., p. 225

[7] Stowers, J. R. and E. L. Kanwit. "The Use of Behavioural Surveys in Forecasting Transportation Requirements," Highway Research Board, Record, 106 (1966), 44-51.

significant features while anticipating and planning for the future. There is an assumption running through most of our transportation planning procedures, however, that observed relationships will somehow hold for lengthy periods of time. For estimates of short-term demand for transport, say five years hence, it is relatively easy to find a model which appears to fit the data in question. If this apparent fit does not represent a set of logical relationships we can hardly expect it to be of use in modeling long-term change. This is a sufficiently important problem to have drawn wide-spread comment, although little progress appears to have been made towards it solution.

> "In predicting the origins and destinations of future travel, the usual method is to assume that the present trip production characteristics will not change through time, and can be directly used to estimate future trips. Recently budget study data and the results from repeat O-D surveys have shown that this assumption is not true, and can lead to considerable errors in future estimates...enough information is available from O-D surveys, economic study groups, market analysis reports, etc. to warrant a serious attempt at a more rational approach to estimating future trip generation characteristics. This research is very essential, as estimates of future trip origins and destinations, interzonal transfers, and the assignment of traffic to the future network all originate from the trip generation characteristics utilized."[8]

---

[8] Martin, B. V., F. W. Memmott, A. J. Bone. Principles and Techniques of Predicting Future Demand for Urban Area Transportation. (Cambridge: M. I. T., Research Paper Report 38), June, 1961.

Both Quandt and Peskin made a similar point in 1965:

> Neglect of behavioural detail and various technical factors is appropriate to forecasting under those circumstances where the factors cannot be expected to change very much during the forecast period. "The longer-term transportation forecast ...requires as deeper investigation of the determinants of travel than has conventionally been the case. Certain of these determinants, which over short time periods can be assumed constant, have changed historically and can be expected to change over long time periods. They include, besides population and wealth, the supply and technical characteristics of transportation facilities. "These longer-term models must specify behavioural and casual relationships that have been largely overlooked in the past."[9]

In the same volume, Quandt points out the need to rethink much of the present theoretical and statistical methodology. He poses a variety of questions which must be answered in the future, including: "what are the theoretical considerations that lead one to expect a priori one or another kind of behaviour with respect to travel?"[10] By 1970, Quandt's discussion of research needs has changed little: in the development of adequate transportation demand functions, more work is needed in a variety of areas, especially:

---

[9]Peskin, H. M. "Some Problems in Forecasting Transportation Demand," Studies in Travel Demand, ed. R. E. Miller, (Princeton, N.J.: Mathematica, 1965), pp. 22-32.

[10]Quandt, R. E. "Introduction", ibid., p. 1.

(a) The specification of the manner in which the attribute variables enter the models.

(b) Specification of the socio-economic theory which underlies the generation of travel.[11]

Carey also points out the need for models sensitive to socio-economic change. The intent of the U. S.-Canadian Conference on Urban Commodity Flow was to develop data sources and demand forecasting techniques (it apparently failed to do the latter) but;

> "It appeared that the collection of data and the design of sophisticated demand forecasting models would not be sufficient. Unless they were sensitive to changing patterns of urban structure, the models would not be valid."[12]

This statement admits that since the future tends to be with us before we have understood the past, there is a need to re-structure our current approaches to transportation research - especially with regard to goods movement.

We are faced with a large specification problem. The careful setting down of functional relationships will be an essential pre-requisite to adequate forecasting. Only as structural relationships based on (a priori) theory replace

---

[11]Quandt, R. E. The Demand for Travel: Theory and Measurement, (Lexington, Mass.: D. C. Heath, 1970), p. 15.

[12]Carey, W. N. "Goods Movement in Cities That Are for People", Paper presented at the Sixth Conference of the International Road Federation, Montreal, October 1970.

empirical relationships based on observed fact can we begin to be confident in, or at least know, the limits to our forecasts.

Units of Analysis

The unit of analysis in the classical urban transportation study has been the traffic zone whose minimum size is normally that of the census tract. The internal variability of these zones is ignored, and this has led to a growing belief "that the size of districts used for forecasting development and travel demand is probably too large to detect the assumed land-use-transportation interactions".[13] Furthermore, after the formulation of alternative plans, "the expected differences (between the plans) in the spatial arrangement of activities may not exist at this aggregate scale."[14]

Alternative pay-offs must be considered in the selection of the size and arrangement of areal units. The ability to forecast travel patterns is low if large areal units are used, although this increases the precision with which trip generation and attraction rates may be estimated. Consequently, by developing improved models which analyze micro-scale transportation demand, we may expect to increase

---

[13] Boyce, D. E., N. D. Day, C. McDonald, Metropolitan Plan Making (Regional Science Research Institute, Monograph Series No. 4, Philadelphia, 1970, pp. 85-87.

[14] Ibid.

both locational precision and explained variation in this demand.[15] One of the few empirical tests of this hypothesis found that:

> "The household (disaggregate) equation produced a much lower magnitude of error when compared to the aggregate procedures. It is recommended that household disaggregate equations be used in trip generation analyses....Disaggregate equations have a more logical basis for producing trip generation results: They represent the true correlation and variability between the variables."[16]

It should be added that a dispute over aggregation extends through other branches of social science, and there is no unanimity on the subject. Grunfeld and Griliches suggested there is a possible gain in information with aggregation in model building on the grounds that we do not know enough about micro-behaviour to specify micro-equations perfectly. Aggregation, they contend, frequently reduces these specification errors.[17] Edwards and Orcutt have countered this by claiming that the ability of aggregate models to respond to changes in the system is much weaker than in

---

[15] Dickey, J. W., F. H. Horton, E. N. Thomas, "Areal Aggregation and Forecasting Precision in Urban Transportation Studies", Tijdschrift voor Economische en Sociale Geografie, 60, 1 (1969), pp. 60-62.

[16] Kassof, H. and H. D. Deutschman. "Trip Generation: A Critical Appraisal." Highway Research Board, Record, 297 (1969) p. 30.

[17] Grunfeld, Y. and Z. Griliches. "Is Aggregation Necessarily Bad," Review of Economics and Statistics, 42 (1960), 1-13.

micro-models, and as a result more disaggregated data are needed to improve policy response models.[18]

It is an assumption of this thesis that the need to analyze micro-systems of activity in urban areas, in order to understand the fundamental bases of spatial behaviour, has been justified by an examination of the general methodological problems encountered in urban transportation research and planning. The most general problem is that models based on aggregate data obscure functional relationships between the variables. This is critical for forecasting over periods where these relationships might be expected to change; a model which cannot account for such changes is suspect when used to estimate future flows of people or goods. Specifically, there is a need for an exposition of the theory underlying the generation of travel, a need to deduce the significant causes of travel prior to empirical analysis.

Irrespective of whether people or goods movement is considered, therefore, an approach to the understanding of the demand for transport in urban areas ultimately relies on a general agreement on the behavioural factors causing this demand to vary through space and time. A review of recent urban goods movement research will confirm this contention.

---

[18]Edwards, J. B. and G. H. Orcutt, "Should Aggregation Prior to Estimation Be the Rule", Review of Economics and Statistics, 51 (1969), 409-420.

CHAPTER III

TRUCK TRIP GENERATION - PREVIOUS RESEARCH

Conceptual Models and Proposed Research Strategies

The only really concerted effort to conceptualize the non-residential land use trip generation problem has been by Shuldiner and others at Northwestern University.[1] The details of their work need not concern us here since they were mainly studying all trips generated by or attracted to commercial and industrial land. Although there may be a high correlation between persons and goods trip generation rates, there is no obvious functional relationship. Furthermore, there is normally no significant spatial correlation between the direction of persons and goods trips or their patterns of trip ends.

---

[1] Shuldiner, P. W. et al. Non-Residential Trip Generation Analysis (Evanston: Northwestern University Research Report, 1965).

________, "Land Use, Activity, and Non-Residential Trip Generation," Highway Research Board, Record, 141 (1966), 63-88.

________, and F. E. Horton, Land Use Linkages Paper presented to the O-D Committee, 45th Annual Meeting of the Highway Research Board, Washington, D.C., January 1966.

Thomas, E. N., F. E. Horton, J. W. Dickey, Further Comments on the Analysis of Non-Residential Trip Generation (Evanston: Northwestern University Research Report, Nov. 1966).

Some of the conclusions to come from the Northwestern group's work may be summarized as follows:[2]

(1) The selection of trip attraction factors appears to be based on three broad criteria:

(a) Logical relationships between a given variable, either singly or in combination with other variables, and the attraction of trips for the particular purposes being considered.

(b) The degree of association evidenced through statistical analysis of a given variable, either singly of in combination with other variables, with the attraction of trips for the purposes of purpose being considered.

(c) The availability of data, its accuracy, or the expense of obtaining it.

Variable selection priorities are usually given in the reverse order, i.e.: data availability appears to be the controlling factor in the selection of trip generation variables; statistical association is used to select from the set of variables used. The logical relationship between the dependent and independent variables may thus become tenuous.

(2) The relative utility of floor space, sales and employment in forecasting should be more fully explored.

(3) Linkages between land uses should be more deeply explored, particularly those that occur on multi-purpose trips and daily trip sets. Also of importance is the effect of separation and contiguity of activities upon trip attractions and trip lengths.

(4) Trip generation is a manifestation of human activity. A high degree of variability is to be expected, particulary in those activities which lie outside formal social or economic systems.

---

[2]Adapted from Shuldiner, loc. cit., 1965 and 1966.

These conclusions suggest that there might be substantial payoffs from an analysis of a "formal" activity system, such as a manufacturing industry, in identifying the "logical relationships" between the variables accounting for truck trip generation rates.

Grava's dissertation attempted to identify "attractive and generating forces of material flow by types of establishment".[3] It was an entirely qualitative description of the channels through which commodities move in an urban environment, and of the modes of transport utilized. It is mentioned here because it made three important contributions:

(1) It is the only explicit recognition <u>and</u> study of the fact that marketing channels and "transportation requirements" are somehow related.

(2) It recognised that different commodities utilize different marketing channels within urban areas.

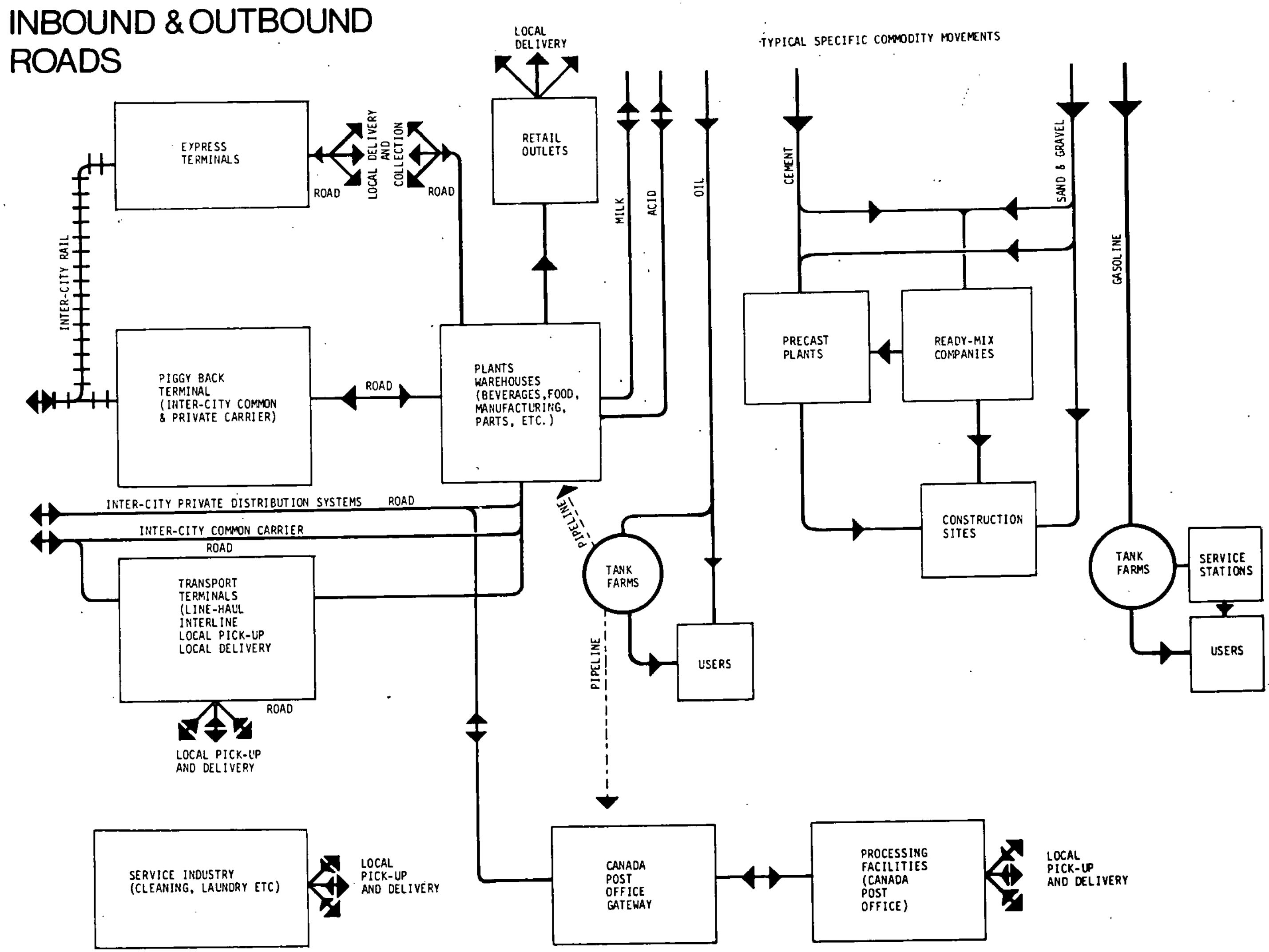
(3) It recognised the interdependence of a wide variety of types of firm and commodity flow.

Grava's work, as he admitted, suffered from the lack of any data to support his arguments about vehicle or goods movement. In fact his main contribution was a flow diagram of commercial and manufacturing activities and their interrelationships in an urban area. Such diagrams are not uncommon in urban planning studies. Figure 1, from the Metropolitan Toronto Plan Review, is presented here to

---

[3] Grava, S. <u>Intra-Urban Freight Movement: Transportation Linkages and Location Requirements</u>. Unpublished Ph.D. dissertation, Columbia University, 1965.

FIGURE 1: PATTERNS OF FREIGHT MOVEMENT



SOURCE: METROPOLITAN TORONTO PLAN REVIEW, EXISTING FREIGHT MOVEMENT SYSTEMS, OCTOBER, 1972.

illustrate this type of abstraction. It can be seen as a preliminary step towards laying the foundations of a full-scale urban goods movement model. However, the data required to calibrate such a model are not available.

Noortman's O.E.C.D. paper mentions, almost incidently, that the distribution channel of a commodity might be related to trip generation rates:[4]

> "....the number of vehicle movements for the same quantity to places of sale for chain-stores is considerably lower than the supply to conventional places of sale."

Noortman did not elaborate on this; he was mainly concerned with the general planning implications of some current trends in commercial location. However, his approach to urban problems associated with goods movement - congestion, rising shipping costs, the undesirable decentralization of certain economic activities - is more subtle than that frequently taken in North America. In a study of wider scope than the development of a marketing model, Noortman's paper would undoubtedly require deeper attention.

The most recently proposed framework for modeling urban goods movement is an extension of the traditional approach to urban transport planning. To the model's authors, it seemed logical "to start with the framework for the analysis of people movement that already exists", but they went

---

[4]Noortman, H. J. "Interrelation Between Urban Movement of Goods and Planning of Urban Areas," Paper presented at the Technology Assessment Review, O.E.C.D., Paris, October, 1970.

on to suggest a variety of problems which would be peculiar to the goods movement model.[5] This, the French-Watson conceptual framework, is shown in Figure 2. The questions we might have of this framework are similar to those asked in Chapter II of the traditional urban transportation study approach: to what extent are predicted changes in goods movement demand based on previously specified relationships between firms or groups of firms, and is it better to use zones of commercial and industrial activity or the individual firm as the units of analysis? This latter question is not answered by French and Watson.

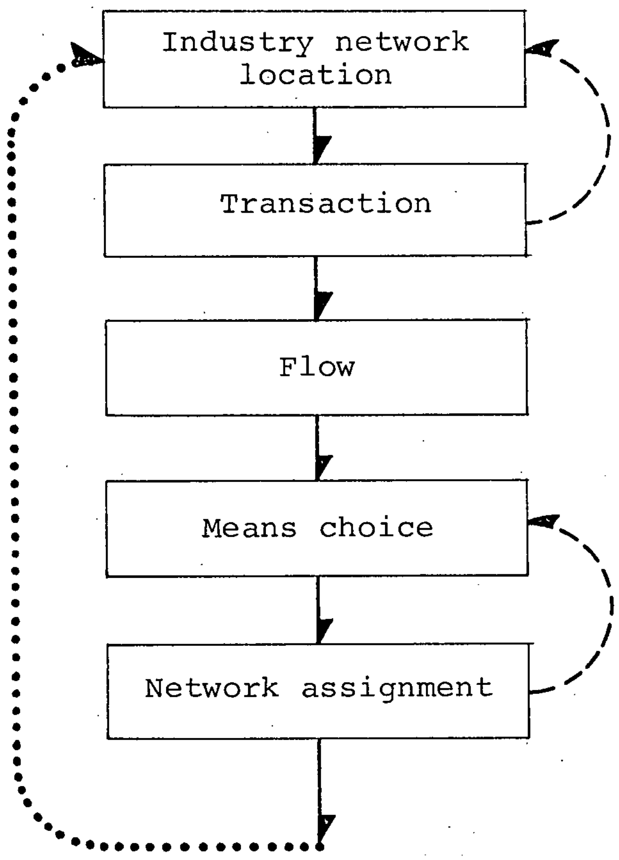
There are several papers and articles with titles which would lead one to believe that there is no shortage of alternative research strategies available. Unfortunately, the majority of these studies are descriptions of the data which seem to be needed, with almost no effort being given to the role these data should play in the construction and operation of working models.[6] The value of descriptive

---

[5]French, A. and P. Watson "Demand Forecasting and Development of Framework for Analysis of Urban Commodity Flow," Panel Report, Urban Commodity Flow, Highway Research Board, Special Report 120, Washington, D. C., 1971, pp. 135-141.

[6]Several papers in Urban Commodity Flow, ibid.
Goss, D. N. et al. Urban Goods Movement Demand. (Columbus, Ohio: Battelle Memorial Institute, 1967).
Hille, S. J. "Urban Goods Movement Research - A Proposed Approach," Traffic Quarterly, 25, 1 (January 1971), pp. 25-38.

Figure 2: Conceptual Framework for Analyzing, Modelling, and Forecasting Urban Goods Movement



——— first-generation sequential

— — — — second-generation internal recycling

•••••••• third-generation fully iterative

Source: French and Watson (1971), p. 138

statistics has been widely recognized as an essential input to the subsequent modelling process, and has been used to identify the facilities available for goods transport, areas of congestion, and many aspects of transport incompatible with an improved urban environment.[7]

Empirical Studies

There are a large number of empirical studies of commercial vehicle activity in cities. Many of these refer to the relationships between goods movement and urban form and structure, particularly the general effects that large scale changes in the density and location of the dominant land uses have had on intra-urban traffic. Good examples of this approach are Chinitz's study of the New York region, and, to a lesser extent, Martin's industrial geography of London.[8]

Another group of empirical studies, and by far the greatest in number, is that which deals with place- and time-specific problems of congestion, high social and economic

---

[7]The C.A.T.S. now has an on-going commitment to the collection and analysis of frieght traffic data in the Chicago area. The Atlas of Freight Facilities (1971) is the first in a series of publications.

[8]Chinitz, B. Freight and the Metropolis. (Cambridge: Harvard University Press, 1960).
Martin, J. E. Greater London: An Industrial Geography. (London: Bell and Sons, 1966).

costs of shipping goods, and a wide range of distinct problems in the movement of goods and commercial vehicles. Most of these advocate rather narrow and technological solutions to problems, and rarely probe for the reasons why problems occur in the first place; these papers do not concern us here.

The third group of empirical research is the one which is the concern of this thesis. This a fairly small group of studies which have attempted to explain variation in trip generation rates from commercial and industrial land uses in terms of certain characteristics of those land uses. The contribution made by any of these studies should be judged by their success in explaining variations in trip distribution as well as generation, for it is frequently possible to analyse both simultaneously, but the discussion which follows concentrates almost entirely on the latter. An appreciation of these studies requires a precise understanding of terminology:

Trip Generation Rate: the number of trips per unit time leaving a particular unit, or class of units, of land use.

Trip Attraction Rate: the corrolary of trip generation rate. Every trip generated by one activity must by definition be attracted by another. Attraction rates equal generation rates if only vehicular counts are considered, but a distinction is made between the two. A trip generated is to deliver goods elsewhere; a trip attracted is to deliver goods at the site.

Shipment: this expression is synonomous with "consignment". It is a good, or a collection or assortment of goods destined for movement between one site and another.

Horwood's study of central Philadelphia was notable for its early, and comprehensive, presentation of the argument in favour of central city freight consolidation schemes. The goods movement characteristics of department stores, specialty stores and office buildings were analyzed, primarily with respect to consignment size and the diurnal variation in trip making.[9] Horwood's research is mentioned here because of two contributions:

(1) He drew attention to the seasonal variations in goods movement volumes to downtown land uses, particularly those associated with retailing.

(2) He observed "the larger the city,....the greater is the probability that it consumes more of its own manufactures. This no doubt increases the percentage of central core imports which come from local vendors and results in a small average delivery per truck or, conversely, a large number of trucks to supply central establishments".[10]

---

[9] Horwood, E. M. "Center City Goods Movement: An Aspect of Congestion," Highway Research Board, Bulletin, 203 (1958).

[10] Ibid., p. 96.

This was not actually tested by comparing Philadelphia with other cities, but it seems to be a hypothesis worthy of further attention in transportation planning. If, by anticipating increases in the urban economic base, we can predict traffic congestion and its distribution we have the rudiments of a long-range planning tool.

Keefer's monograph on the travel patterns associated with specific land uses was mainly concerned with the distribution of trips, both automobile and truck. The study took a very general approach, and was based on data available from a variety of cities. The conclusions of interest to trip generation research are rarely more precise than: "there seems to be a slight tendency for smaller plants to develop higher truck trip rates" because "it does seem reasonable that the larger plants would tend to rely more on rail and water shipments".[11]

Research in Europe and the U. K. appears to have produced more specific results, if not greater real progress, in explaining the variation in commercial vehicle traffic at non-residential land uses.

Williams and Latchford pioneered U.K. research in the field.[12] Their study of industrial estates in northeast

---

[11]Keefer, L. E. Urban Travel Patterns for Airports, Shopping Centers, and Industrial Plants. (Washington: National Cooperative Highway Research Program Report No. 24, 1966), p. 69.

[12]Williams, T. E. H. and J. C. R. Latchford. "Prediction of Traffic in Industrial Areas," Traffic Engineering and Control, (Dec. 1965 - April, 1966).

England did not, unfortunately, distinquish commercial vehicle trips; instead all vehicular trips were correlated with employment and floor space at industrial sites. Consequently, extremely high correlation coefficients were found between vehicular trips and employment or floor space. This is to be expected, at least in the case of employment. The reason for high correlations between trips and floor space is rather difficult to explain and its frequent use has never been satisfactorily defended. However, there was on exception to Williams and Latchford's apparent success; clothing and textile firms did not conform to the model. Since there were four industries analysed, a 25% failure rate gives cause to doubt the usefulness of the simple linear model in predicting vehicle trips based on employment alone. Furthermore, the Williams and Latchford series of papers must be regarded as inconclusive - the number of firms in each of the four sample industries ranges from seven to eleven.

In a later but similar type of analysis, Maltby separated commercial vehicle from automobile trip generation for his study of 23 industrial plants in Sheffield.[13] His results demonstrate what we expected from Williams and Latchford's approach: a model in the form;

$$Y = a + bx$$

where: Y = commercial vehicle trips attracted or generated per day

X = employees

---

[13]Maltby, D. "Traffic at Manufacturing Plants", Traffic Engineering and Control, 12, 2 (June, 1970), pp. 72-77.

is much less satisfactory for estimating truck trips than it would be where Y = automobile trips. Of eight equations with Y alternatively commercial vehicle attractions and generations and X as employment or floor space for various groupings of firms only two were assessed as significant by Maltby. Of the equivalent eight for automobile trips, only one was given as insignificant.

Certainly the most useful analysis of truck trip generation rates at non-residential - in this case industrial sites - was Starkie's Medway Towns study. It has several advantages over the previously mentioned attempts to explain trip generation rate variation between industrial sites. It was a survey of 77 sites; it focussed on the commercial vehicle; statistical analysis was more competently presented; and it attempted to explain non-linearities in the relationships.[14]

Using the linear model, Starkie found a correlation coefficient of 0.496 for truck trips on employment and 0.607 for truck trips on floorspace. The latter coefficient was somewhat unexpected, for Starkie had reasoned that employment should probably be a better predictor trip generation than floorspace. Unfortunately a plot of the data at this stage (for all 77 plants) was not made available; it is possible that the correlation coefficients could have been influenced

---

[14] Starkie, D. N. M. Traffic and Industry: A Study of Traffic Generation and Spatial Interaction. London: London School of Economics and Political Science, Geographical Papers No. 3, 1967.

by a few extreme values. However, the high alpha coefficients (27 and 19 respectively) indicate that the regression equations overpredict trip generation values for small firms. This fact went unnoticed by previous studies, but it led Starkie to transform both variables to their logarithms. This gave the following results:[15]

$$\log Y = 0.257 + 0.559 \log X_e \qquad (r = 0.732)$$

$$\log Y = -1.175 + 0.572 \log X_f \qquad (r = 0.775)$$

where: Y = commercial vehicle trips per day per plant

X_e = employment per plant

X_f = floorspace per plant (sq. ft.)

Not only did the transformation raise both correlation coefficients, especially for X_e, but the alpha value was significantly reduced. One may argue with Fleischer that "almost anything looks better on double log. paper", but Starkie gave what appear to be plausible explanations of the apparent "economies of scale in trip generation" - that larger firms are able to increase load factors of vehicles, and that firms are likely to establish new departments in the early stages of growth. Starkie was unable to test either of these suggested causes of non-linearity.

A sub-set of the data - the "engineering, metalworking, and allied trades" plants (37) - was extracted for

---

[15] *Ibid.*, p. 32.

separate analysis.[16] The reason behind this was the suspicion that much of the variability in trip generation rates could be accounted for by an examination of the "type of work undertaken at the manufacturing plants". This subset analysis generated the following equations:

$$Y = 21.826 + 0.034 \ X_e \qquad (r = 0.774)$$

$$\log Y = 0.401 + 0.500 \log X_e \qquad (r = 0.931)$$

Starkie had already rejected floorspace as a useful variable, mainly on the grounds that it was insignificant in sub-set analyses, but he gave no statistical proof of this. Again we have seen the case of an apparently good fit between trip generation rates and employment. Unfortunately, the high r value can be attributed to the existence of some 5 or 6 firms with employment totals ranging from approximately 1000 to 10000. Well over half the firms have employment totals of less than 100. Consequently, it is not surprising to find a very wide range of trip generation rates for the low values of X_e. Starkie returns to the other firms (non-engineering, etc.) and proceeds with a qualitative analysis of the probable reasons for observed residuals from the overall regression line. The explanation he normally uses is differing degrees of labour intensiveness, but also discourses briefly on the fact that access to and use of rail or wharf facilities could decrease truck trip generation rates.

---

[16] _Ibid._, p. 34.

Fleischer's remark was made in Fleischer, A., "On Prediction and Urban Traffic," _Papers and Proceedings of the Regional Science Assocation_, 7 (1961), pp. 43-50.

The second contribution of Starkie's monograph was his analysis of the spatial distribution of trips from the Medway Towns using various formulations of the gravity model. The distribution model analysed the distance-decay in trip making from the Medway Towns area as a whole, rather than individual plants, and consequently gave no indication of its significance for trip generation rates at different land uses. This is a problem with all the available tests of interaction models based on zonal averages.

Efforts to explain the decrease in trip-making with increasing distance have been generally unsuccessful when applied to short distance goods movement. Helvig found: "the gravity model formulation estimated truck trips to the Chicago area reasonably well for larger areal units such as states and counties" but "distance is not....important in determing truck trip volumes at the local level".[17]

Similarly, part of Hoel's contribution was an application of the gravity model to inter-zonal movements of trucks in the Los Angeles area, and he found the model to be largely ineffective.[18] The basic reasons for this are

---

[17]Helvig, M. Chicago's External Truck Movements. (Chicago: University of Chicago Press, Department of Geography Research Paper No. 90, 1964), pp. 115-116.

[18]Hoel, L. A. A Study of the Utilization of Trucks for Transport in Urban Areas. Unpublished Ph.D. dissertation, University of California, Berkeley, 1963.

that the total costs of owning and operating commercial vehicles in urban areas are high, but the greater part of these costs are fixed - wages, equipment, and terminal costs, including congestion at shipping and handling points. The incentive to reduce line haul distance in urban areas is therefore probably quite low for many trips. Also the pattern, and therefore length of commercial vehicle trip making, is determined by the pattern and location of trip ends, and in turn the location of trip ends is determined by a wide range of factors which may or may not be related to truck access.

Hoel's dissertation, while primarily concerned with the Los Angeles Region Transportation Study, gave an interesting insight into the influence of the vehicle and commodity on truck trip generation rates.[19] Hoel's argument is as follows:

Assume that the weight of goods generated by each (industrial) establishment is known and that one vehicle type of constant weight capacity is used to ship these goods to their destinations. If all trucks are fully loaded, the number of trips based on the weight capacity of truck is -

$$N_w = \frac{W_c}{W_t}$$

where: N_w = number of truck trips based on truck weight capacity.

W_c = total weight of commodity

W_t = weight capacity of the truck.

---

[19] Hoel, *ibid.*, pp. 70-73.

Assume that the truck type has a maximum volume capacity, and the density of the (packaged) commodity is d_c. The number of trips based on the volume capacity of the truck is -

$$N_v = \frac{V_c}{V_t} = \frac{W_c}{d_c V_t}$$

where: V_c = total volume of the shipment

V_t = volume capacity of the truck

d_c = shipment's density

The critical commodity density is given by the ratio of the truck's weight capcity to its volume capacity where weight and volume criteria result in the same value of N. Where $d_c > (W_t/V_t)$, for $N_w = N_v$, then the weight capacity of the truck will determine the quantity of the commodity shipped; if d_c is less than the critical commodity density, then the volume capacity of the truck will determine the quantity.

Trucks are, in urban areas, fairly infrequently loaded to their full capacity. The degree to which a truck is loaded below capacity is expressed by the load factor (K_w or K_v)

$$K_w = \frac{W_a}{W_t}$$

where: W_a = average weight of shipment over some period of time.

if this average shipment weight is known, then the number of truck trips over the same period of time is:

$$N'_w = \frac{N_w}{K_w}$$

where: N_w = minimum number of trips possible with full loads

N'_w = actual number of trips allowing for the average value of K_w.

Of course the subscripts (w) may be change to (v) to give the effect of volume restrictions.

Hoel noted the stringent data requirements to test this model, particularly those relating each shipment to its vehicle's capacity, and he was not able to use the L.A.R.T.S. data to provide a test. We may note, however, that it does suggest the role that vehicular technology and government regulations might play in affecting trip generation rates in those activities which strive to maximize the load factors on commercial vehicles; if Hoel's relationships can be quantified, we would have an estimate of the effect of changes in the capacity of trucks, technical or regulated, on trip generation rates.

A few other studies have taken an approach similar to the ones discussed above, but they have added little to our current stock of knowledge or seriously considered ways of improving predictive models of truck trip generation rates.[20] An exception is the input/output approach used

---

[20]Bates, M. V. "The Trucking Industry and Urban Development," Unpublished report, (Toronto: Smith Transport, 1968).

Eliot-Hurst, M. E., "An Approach to the Study of Non-Residential Land Use Traffic Generation", Annals of the Association of American Geographers, 30, 1 (1970), pp. 153-173.

Wilbur Smith and Associates, Motor Trucks in the Metropolis, (New Haven, Conn.: Wilbur Smith, August, 1969).

by Hutchinson at the University of Waterloo, which is designed to combine interregional commodity flow data for Ontario with truck trip and modal split estimates to forecast future interregional freight transport flows. It is interesting to note that the method still relies on adequate models of trip generation and attraction rates. For the Waterloo Study, a field survey of manufacturing establishments in the Toronto region was conducted to produce the following equations:[21]

Light Trip Generators (firms producing confectionaries, shoes, carpets, clothing, commercial printing, small electrical appliances, communication equipment)

$$Y_p = 7.231 + 0.018.X_1 \qquad r^2 = 0.182$$

$$Y_a = 6.803 + 0.191.X_2 \qquad r^2 = 0.205$$

Medium Trip Generators (firms producing canned foods, pulp and paper mills, paper boxes and bags, hardware and cutlery, major appliances).

$$Y_p = 10.852 + 0.024.X_1 \qquad r^2 = 0.472$$

$$Y_a = 10.412 + 0.037.X_1 \qquad r^2 = 0.560$$

Heavy Trip Generators (firms producing meat products, bakery products, soft drinks, brewery products, newspapers, ready-mix concrete, clay products.

$$\log_e Y_p = 2.701 + 9.270.\log_e X_3 \qquad r^2 = 0.457$$

$$\log_e Y_a = 2.375 + 0.268.\log_e X_3 \qquad r^2 = 0.256$$

where: Y_p = truck trips products (origins) by an industry

Y_a = truck trips attracted (destinations) by an industry

---

[21] Hutchinson, B. G. "Forecasting Inter-Regional Commodity Flows", Paper presented at the NATO Conference on The Application of Operational Research to Transport Problems, Sandefjord, Norway, August 1972.

X_1 = male manufacturing employment in the industry

X_2 = male office employment in the industry

X_3 = private trucks available to the industry

Only a few major urban commodity flow surveys have been conducted, two recent examples being those in New York City and Calgary.[22] Both these surveys were of truck rather than commodity movements, and both were investigations of a situation in particular cities, rather than data collected to support a hypothesis or even calibrate a forecasting model. In other words, like similar projects before them, such surveys have not been based on theoretical structures which are necessary for long-range planning. This is not to say that the data actually generated have not and may not lead to improvements in urban systems of commodity flow. The Tri-State's Region's ideas for consolidation of shipments (as yet unimplemented) arose directly from their 1960's survey work.[23] A

---

[22]Tri-State Transportation Commission, New York: "Characteristics of Internal Truck Freight", (Report 4042-3512), June 1966. "Truck Freight in the Tri-State Region", (Report 4095-6053), October 1968. "Truck Freight Activity at Selected Terminal Areas in the Tri-State Region", (Report 4102-6591). "Truck Freight in the Tri-State Region", (Report 4143-1610), October 1969. "Truck Freight in the Garment District", (Report 4156-1610), December 1969.

Wood, R. T. "Measuring Urban Freight in the Tri-State Region", Paper presented at the Technology Assessment Review, O.E.C.D., Paris, April 17, 1970.

Transportation Development Agency, Urban Goods Movement: Calgary Survey Method, Phase II, (Montreal: T.D.A., to be published).

[23]Interview with Robert Wood, Tri-State Transportation Commission, July 1972.

real disadvantage of surveys such as these is that truck movements which receive greatest attention are those of for-hire carriers, whereas the majority of dommercial vehicle trips are by private or institutional carriers. The reason for this emphasis is that for-hire operators own the largest urban trucking fleets, and consequently the number of operators per truck whose cooperation is required is relatively low.

In sum, to this point, zonal average models have been widely criticized for their many inadequacies. A more promising approach has been the identification of distinct classes of non-residential activity in order to minimize as much as possible variations in trip making rates attributable to site function. Even this leaves a suspiciously large amount of unexplained variation in the data, and no firm base on which to estimate future trip generation rates.

The most profitable future directions of truck movement research have been indirectly suggested by a small group of writers, especially those whose contributions have been reviewed in this chapter. We may expect to see attempts to formally structure the theoretical underpinnings of research and planning methodologies. This will probably come about through analysis of micro-scale transport behaviour, (in which the unit of analysis is the individual economic unit, i.e. the firm) and through the testing of hypotheses about the factors assumed to be causally associated with the demand for vehicle movements. Chapter IV discusses a set of relationships which may improve on our current understanding of variations in truck trip generation rates.

CHAPTER IV

TOWARDS A MARKETING MODEL OF TRUCK TRIP GENERATION

As a result of the foregoing reviews of urban transportation studies generally, and urban goods movement research in particular, we can isolate the following critical deficiencies in methods of estimating urban truck transport demand:

(1) The selection of variables used to forecast the volume of truck movement from a zone or site normally takes data availability as its dominant criterion. However, data availability should be a constraint only; the explanatory variables selected should depend primarily on a previously established causal logic.

(2) The demand for vehicle (truck) movement is closely related to the demand for goods movement. No advantage has been taken of this fact by means of attempts to ultimately relate vehicle movement to industrial location and structure theories and models.

(3) The demand for truck movement can vary according to the level of modal competition. This is usually discounted in urban areas, despite the fact that cities are important nodes on rail, water, pipeline and air networks.

(4) The demand for truck transport, which in this study is measured by the generation rates, is not only related to the demand for goods movement (2, above) but also to the nature of truck transport supply. For example reduced vehicle capacity tends to increase trip generation rates. Also it will be seen in this chapter that the incidence of truck ownership is significant for trip generation rates.

(5) Firms vary not only according to their within-site characteristics, such as employment size, but also according to their markets. No urban goods movement empirical studies have studied the effects of variation in market characteristics, except to estimate the effect of <u>distance</u> to market. Effect of other characteristics, especially the size of shipment normally ordered by different types of customer have not been identified.

This chapter discusses these deficiencies in detail, and in the following order. First, the concept of "the demand for truck transport" is discussed. The possible complication of competition with other modes of transport is dismissed because of the almost total dominance of truck transport for short distance trips, but it is observed that the nature of inter-city truck transport demand varies between different industries.

Secondly, the possible effects of <u>truck transport</u>

supply on trip generation rates are discussed. Unfortunately there is no previous research available from which to deduce these effects, so a typical pattern of movement from one manufacturer is described, and the different trip generation rates under different truck capacities and truck-ownership conditions are noted.

Next, the possibility of industrial location theory contributing towards knowledge of the magnitude of the demand for truck trips is explored. It is concluded that location theory itself will ultimately be tied to trip distribution research, and that the analysis of inter-firm linkages, a subset of location theory, may in the future be part of trip generation studies. However, further research is required in both linkage analysis and urban goods movement before a unified model can be constructed.

Fourthly, having rejected the general tenets and findings of location and linkage analysis as being of limited relevance to truck movement models at present, concepts from industrial structure and physical distribution research are reviewed. This proves to be a more fruitful area of investigation. Different approaches to the analysis of physical distribution channels are reviewed, as are alternative types of firm behaviour within channels. This discussion leads to speculation on the effects of channel structure and behaviour on transportation demand. The large number of cause and effect relationships identified cannot all be quantified in one case study; this will come over time as data sources improve. However one hypothesis seems sufficiently strong and capable of quantification that it forms the basis of the case study which follows in Chapters V and VI: this is the hypothesis that trip generation rates vary between manufacturers depending on the institutional (role in the channel of distribution) characteristics of their immediate customers.

The Demand for Truck Transport

Until now we have ignored, as have other trip generation studies, the role of other modes of transport in goods movement originating at non-residential sites. Also, the modal split question will not enter our model explicitly, so it is important to realize now that its consideration should be part of any fully comprehensive goods movement study which may be carried out in the future.

National and regional data on the factors influencing aggregate decisions to ship commodities by truck, rail, water, etc. are readily available, at least for the U.K. and U.S.A. Church and Buhl, in their studies of U.S. Census data, found that increases in plant size and spatial extent of the market were both associated with decreases in truck transportation and increases in other modes. This is illustrated for the lumber and wood products group in Table 2 (1). The industrial classification is into 24 "shipper groups". The relationship between plant size, extent of the market, and share of total shipments moving by truck

TABLE 2

HIGHWAY SHADE OF INTER-CITY COMMODITY TRAFFIC, U.S.

TABLE 2 (1)

Highway Share of Total Tons of Lumber and Wood Products, U.S.A.: Average Shipment Length

Lumber and Wood Products Group (size of firm - employees)	Truck Share of Total Tons - %	Size of Market (ave. mls from plant) Truck Shipments	Total Shipments
20 - 99	50.8	214	581
100 - 499	35.3	232	890
500 +	16.1	264	1119

Source: U.S. Census of Transportation, 1967, Vol. 3, Par 1, Commodity Transportation Survey.

TABLE 2 (2)

Highway Share of Intercity Shipments by Manufacturers in Selected States and Production Areas

State	Highway Share	Production Area	Highway Share
Washington	23.9	Seattle**	29.7
California	49.1 (61.9)*	San Francisco	46.8 (64.3)
		Los Angeles	47.5 (68.8)
Illinois	51.7 (54.0)	Chicago	53.0 (53.9)
Indiana	56.7 (55.6)		
New York	52.2	New York	77.8
Massachusetts	81.1	Boston	87.6

* Parentheses indicate exlusion of petroleum and coal products.

** Production Areas comprise one or more S.M.S.A.s:

<u>Seattle</u>: Seattle-Everett; Tacoma.
<u>San Francisco</u>: San Francisco-Oakland; Vallejo-Napa; San Jose.
<u>Los Angeles</u>: Los Angeles-Long Beach; Anaheim-Santa Ana-Garden Grove; San Bernadino-Riverside-Ontario.
<u>Chicago</u>: Chicago, Ill.; Gary-Hammond-East Chicago, Ind.
<u>New York</u>: New York, N.Y.
<u>Boston</u>: Boston; Worcester; Providence-Pawtucket-Warwick; Brockton; Lawrence-Haverhill; Lowell.

Source: U.S. Census of Transportation, 1967, Vol. 3, Part 2, Commodity Transportation Survey

TABLE 2 (3)

Highway Share by Distance and Weight, of Lumber and Wood Products

Weight (lbs)	Under 200 mls			200-399 mls	400-599 mls	600-999 mls	over 1000 mls
	Motor carrier	Private truck	Total				
under 1000	63.7	34.4	98.1	96.1	95.2	92.0	86.1
1000-9999	26.7	70.4	97.1	96.9	93.7	92.6	62.6
10000-29999	17.7	80.2	97.9	91.3	81.1	60.0	9.4
30000-59999	23.2	70.1	93.3	88.4	78.9	40.9	26.2
60000-89999	7.3	23.7	31.0	4.8	7.0	1.3	0.5
over 90000	9.6	12.0	21.6	9.0	3.7	1.8	1.1

Source: U.S. Census of Transportation, 1967, Vol. 3, Part 3, Commodity Transportation Survey were observed for all other groups as well. However, there were no similarities of individual data between groups: although there is generally a decrease in quantity shipped by truck as firm size and market are increases, neither the rate of the decrease nor the highway transport share are similar between different industries. This suggests that the analysis of distinct types of industry based on product alone is justified in studies of transportation demand. This is also borne out by the differences observed in the highway share of all manufacturers by state and S.M.S.A. (Table 2 (2)). Finally we may note the reason for not considering the mode split problem at the intra-urban scale in this thesis: almost all the shipments under 60,000 lbs moving less than 200 miles are by truck, (Table 2 (3)).[1]

Discriminant functions have been developed which estimate share by various modes, usually private truck, commercial truck, and rail, of either the total regional or national budget (in ton-miles) or their incidence in various industries.[2] The discriminant approach finds that linear

---

[1]Church, D. E. "Impact of Size and Distance on Intercity Highway Share of Transportation of Industrial Products," Highway Research Board, Record, 175 (1967), 1-8.
Buhl, W. F. "Intercity Highway Transport Share Tends to Vary Inversely With Size of Plant," ibid., pp. 9-14.

[2]Miklius, W. "Estimating Freight Traffic of Competing Transportation Modes: An Application of the Linear Discriminant Function," Land Economics, 45, 2 (1969), pp. 267-273.
Bayliss, B. T. and S. L. Edwards. Industrial Demand for Transport. (London: H.M.S.O., 1970) pp. 144-157.
See also:
Warner, S.L. Stochastic Choice of Modes in Urban

combination of measurements characterizing shipments which best discriminates between two modes of transportation. As might be expected, the weight of shipment is normally the most significant independent variable since, at the firm's level of decision-making, shipment size is frequently determined simultaneously with modal choice.

The term "demand" for transportation has been used in this thesis in a sense divorced from economic theory. "Demand" as used here indicates quantities of commodities or transportation services actually consumed without specific reference to price or other monetary variables. In its true economic sense, demand may be defined as a "potential subject to actualizing within the restraints imposed by the availability of some financial resource".[3] Truck trip generation is one measure of the demand for commercial vehicle transport, but this thesis views it purely as derived demand - that is it varies in accordance with the demand for the commodity being transported. There is evidence that this is a reasonable assumption, at least on the national scale. Bayliss found a significant positive

---

Travel: A study in Binary Choice. (Evanston: Northwestern University Press), 1962.

Quarmby, D. A. "Choice of Travel Mode for the Journey to Work", Journal of Transport Economics and Policy, (1967), pp. 273-314.

[3]Putman, S. H. "An Integrated System of Models for the Analysis of Urban Transport Interfaces", Transportation Journal, 10, 3 (1971), 39.

correlation between industrial production and the demand for transport services in the U.K. and Germany.[4] However, it may be a less reasonable assumption at the local level; many observers have noted that trucks in urban areas are frequently loaded below capacity, and an increase in commodity flows could cause an increase in load factors and not in vehicle trips.

The uses of demand theory become more relevant at the inter-urban scale where it is the most apparent that substitutes for truck transportation exist.[5] Unless there are significant substitutes in urban areas, we may assume that the intra-urban demand for truck transportation can be estimated from a knowledge of the demand for goods movement.

Truck trip generation rate analysis would have to take into account the capacity of vehicles and average load factors: these two variables can be assumed to be constant in only a few specialized cases: cement haulage and some waste disposal operations for example.

The demand for truck transportation of a commodity is, therefore, at least in part a function of the demand for that commodity. There is one circumstance where

---

[4]Bayliss, B. T. European Transport, (London: Kenneth Mason, 1965), 18.

[5]See especially: Perle, E.D. The Demand for Transportation: Regional and Commodity Studies in the United States. (Chicago: University of Chicago Press) Department of Geography Research Paper No. 95, 1964.

truck transport may not be almost totally responsive to commodity demand, and that is where significant transport mode substitutes exist. This is normally the case in inter-city transport, but not at the intra-urban scale, or indeed for most short-distance movements. Perle found that inter-city truck transport demand was quite highly price elastic, and that railway service provided an important substitute mode.[6] More detailed analysis, by commodity and region, revealed that growth in truck transport market share was probably due more to changing commodity composition and absolute market growth rates than pricing considerations.[7] Furthermore, Perle's and other studies, in passenger transport especially, indicate that cross elasticities of demand are possibly more significant than direct elasticities.[8] Since no transportation substitutes effectively exist for trucks in the urban commodity distribution process (i.e. the market share of the trucking industry approaches 100%) we can only be concerned with direct price elasticities.

An important exception to this generalization is that storage of commodities may be substitutes for their transportation. This is encouraged by the economies of

---

[6] Ibid., 42-43.

[7] Ibid., 119-120.

[8] Lave, L.B. "The Demand for Intercity Passenger Transportation", Journal of Regional Science, 12, 1 (April, 1972), 71-84.

scale associated with shipping truck-load lots, a question which will be discussed later in this chapter under the subject of physical distribution channel behaviour.

For the urban trucking industry as a whole then, we may expect demand to be inelastic with respect to price; that is to say, a decrease in the price of trucking does not result in an increase in total expenditures on trucking. For the individual trucking company, however, demand is probably highly elastic. Under conditions which approach pure competititon - many small firms, a homogeneous product, and free mobility of resources - a small increase in price may lead to a drastic decrease in revenue. Clearly the urban trucking industry is closer to this condition than any other segment of the goods transport market. In fact the elastic demand curve for the individual firm counters the inelastic curve of the industry as a whole. Another factor holding down the price charged by the individual trucking company is the option open to nearly all buyers of providing their own truck transport. The logical conclusion is therefore that the price charged by the trucking company cannot be used as a weapon to increase revenue, and that the major part of any increase in revenue will come from changes in the type and volume of commodity being transported, which in turn is largely beyond the control of the trucking industry.[9]

---

[9]These generalizations about pure competition can

The Supply of Truck Transport

The demand for urban truck transport, therefore, is directly related to the demand for commodities. However the supply of truck transport is not homogeneous, since truck capacities vary and intensities of truck utilization vary among firms. It is the possible effect of variations in supply on trip generation rates which are now examined. Unfortunately, no readily available data exist which relate truck transport supply to demand, especially where demand is measured in number of trips. Consequently, primitive but realistic data on the costs, revenues, and operating schedule of a shipper of a homogeneous commodity are analysed here in order to derive the effects of supply changes on trip generation rates. The data are based on the case facing a manufacturing firm in Greater Vancouver, B.C.

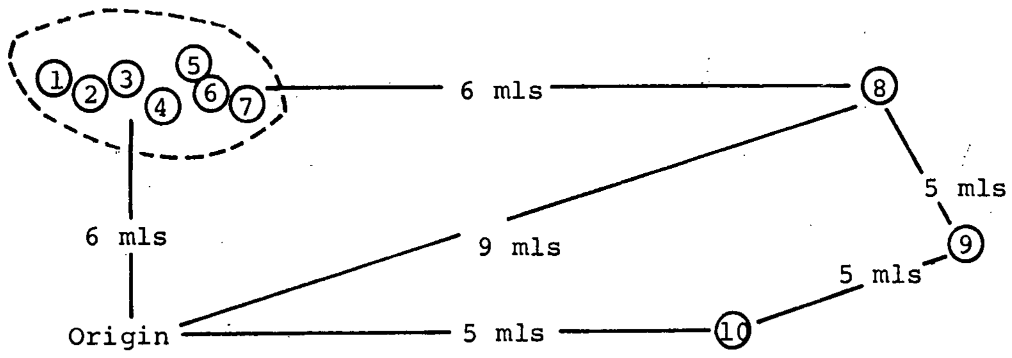
Figure 3 shows the initial condition of the manufacturer serving customers 1-4, short-run variable costs facing the manufacturer's own trucking fleet, and a simple level of demand. Although the cost data used in this example are believed to be fairly representative in terms of their relative magnitudes, net revenues are probably

---

obviously be qualified by observing that some trucking companies are unusually large, and therefore probably have some degree of market control, many do offer differentiable services, which may include special equipment, or direct connections with points outside the city. Also, entry into the industry is not free of constraints: it is subject to provincial regulation and requires a reasonable investment of capital, materials, and labour.

Fig. 3

Hypothetical Distribution System



Truck capacity 3 units
Demand per day: 1 unit per customer
Freight rate: $4.00 per unit
Transportation cost: $0.50 per mile - $1.50 per delivery
Distance between adjacent customer 1 - 7: 1 mile.

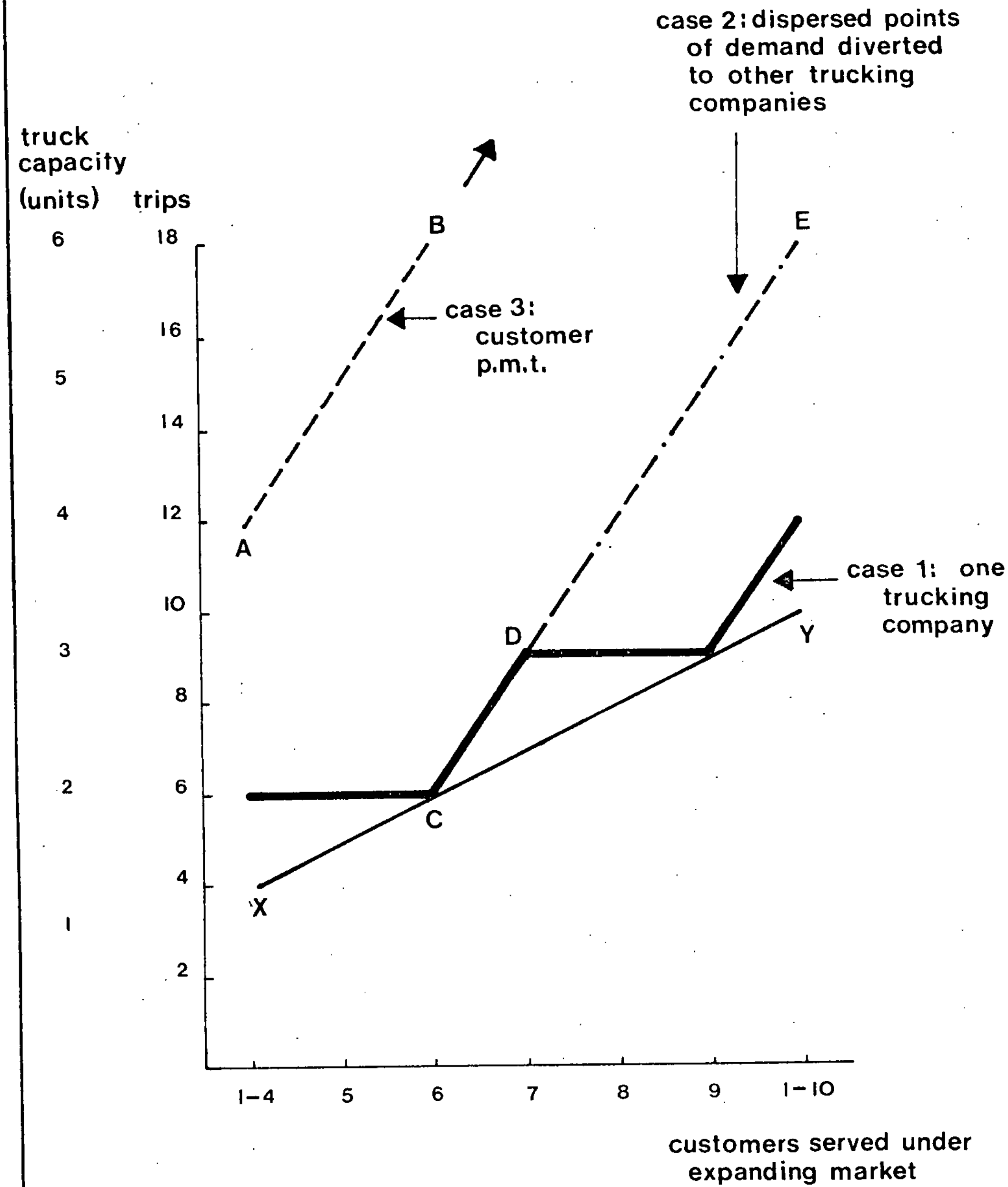
Market (customers)	Trips to customers	Revenue $	$ Cost Line Haul	Delivery	Total	Revenue	Net Revenue /Total Cost
1 - 4	1, 2	8.00	3.50	3.00	6.50	3.00	0.23
	3, 4	8.00	3.50	3.00	6.50		
1 - 5	1, 2	8.00	3.50	3.00	6.50	5.00	0.33
	3, 4, 5	12.00	4.00	4.50	8.50		
1 - 6	1, 2, 4	12.00	4.00	4.50	8.50	7.00	0.41
	3, 5, 6	12.00	4.00	4.50	8.50		
1 - 7	1, 2, 4	12.00	4.00	4.50	8.50		
	5, 6	8.00	3.50	3.00	6.50	6.50	0.30
	4, 7	8.00	3.50	3.00	6.50		
1 - 8	1, 2, 4	12.00	4.00	4.50	8.50		
	3, 5, 6	12.00	4.00	4.50	8.50	6.00	0.23
	7, 8	8.00	6.00	3.00	9.00		
1 - 9	1, 2, 4	12.00	4.00	4.50	8.50		
	3, 5, 6	12.00	4.00	4.50	8.50	6.00	0.20
	7, 8, 9	12.00	8.50	4.50	13.00		
Or 1 - 9	1, 2, 3	12.00	4.00	4.50	8.50		
	5, 6, 7	12.00	4.00	4.50	8.50	4.50	0.14
	4	4.00	3.00	1.50	4.50		
	8, 9	8.00	7.00	3.00	10.00		
1 - 10	1 - 7	28.00	11.00	10.50	21.50	6.50	0.19
	8, 9, 10	12.00	7.50	4.50	12.00		

unrealistically high. In the long run especially, most urban trucking companies are probably operating on profit levels of less than five percent.

Net revenue/total cost is shown for an expanding market for the commodity. Serving a concentrated market is not only the most profitable activity for the trucking firm, but this market supports losses in more dispersed markets. In reality, markets are roughly segmented among firms in the trucking industry, at least in the larger urban areas. In Figure 3 we would probably see some of the dispersed business (customers 8, 9, and 10) allocated to other trucking firms. This process of spatial segmentation of markets is readily observable at the interregional scale; here it is suggested that it may apply at the urban scale as well.

With the growth in the demand for a commodity in an urban region, therefore, one of two general effects on trip generation rates may occur. These are shown in Figure 4, which is an alternative representation of Figure 3. XY is the increase in market demand, and the affect on trip generation rates of an expanding market is demonstrated (vertical axis). Along XC, average load factors on vehicles are steadily increasing, until an increase in truck capacity is required (CD). This step-wise change in trip generation rates continues as market demand increases. The larger the manufacturing firm, the smaller the ratio of truck capacity to total production, so we might expect the step-wise

Figure 4: **Impact on Truck Trip Generation Rates of Different Market Densities and Transport Supply**



id/hs

characteristics to blur into a straightline relationship for large volumes of commodity transport. However, for smaller firms, these sudden changes in capacity at points such as C may make estimation of trip generation rates of smaller firms quite difficult.

It was suggested that dispersed points of demand might be served by different trucking companies (Figure 4, DE). If expansions and contractions in the manufacturer's market take place throughout the whole urban area, we may expect much wider fluctuations in trip generation rates than where changes occur in the same concentration of demand.

Manufacturers have the option of using PMT (private motor transport). Oi and Hurter found that the existence of PMT was associated with large firm size and the opportunity for high load factors.[10] This is supported by our model in Figures 3 and 4. Load factors do tend to increase with increased plant output, especially with concentrated market. Even where load factors do not significantly increase, it might be expected that the alternative - dealing with an increasingly large number of trucking companies - is an incentive to introduce PMT. In this case there may be economies in centralized scheduling of

---

[10] Oi, W. Y. and A.P. Hurter, Economics of Private Truck Transportation (Dubuque, Iowa: W. C. Brown, 1965), Ch.4.

shipments. Between for hire carriage and PMT there is a grey area of contract trucking. Normally this is easily defined: An independent trucking company is contracted to haul a commodity within a specified area for a set period of time. Sometimes contract carriage may be mistaken for PMT, especially in cases where exclusive use of rented vehicles and drivers is involved, resulting in not only visual association of the vehicle with the manufacturer's firm, but also a vehicle-use pattern which is identical with that of PMT.

Differences in trip generation rates between firms using PMT and those using for hire carriage may therefore be primarily attributed to the market for the product rather than any intrinsic differences between the two modes.

It has been observed that the demand for truck transportation in urban areas can be identified through analysis of the demand for commodities and that the supply of truck transportation, while ubiquitous at a price, is affected by load factors on vehicles, their capacity, and some spatial characteristics of the market for the commodity. Trip generation rates are therefore expected to be influenced by the degree of spatial concentration in the market for the commodity.

Three important factors may cause marked deviations from this general model:

(1) Vehicle capacities vary substantially. If, in Figure 3, one of the vehicles had a capacity of 4 units

and the others 3 units, it would be possible to serve the market (1-10) with three trips instead of the four actually taken.

(2) Truck transportation from the point of supply of a commodity may not be carried out by a centralized, optimizing agency - either a single for-hire firm or PMT operated by the manufacturer. There are two alternatives: (a) each customer provides his own PMT, (Figure 4, AB) or (b) the market could be divided among different trucking companies according to their market specialization. In the latter case four companies might serve the originating site: one for customers 1-7 (3 trips) and one each for customers 8, 9, 10 (3 trips), as shown in Figure 4, XCE.

(3) Storage of commodities may occur anywhere in the physical distribution system, that is at points of shipping, transit, or receiving. In-transit storage is insignificant within urban areas, although it is important for some commodities on a regional or national scale. The other cases are extremely significant: either the shipper (in this case a manufacturer) or receiver may stock up the supply of a commodity to allow shipment in truck-load lots. To the extent to which this occurs, trip generation rates become a function of total demand and truck capacity. Where stocking is less important, trip generation rates will be more a function of storage space available. In the extreme (hypothetical) case of zero storage space, trip generation rates correspond directly to the <u>frequency</u> of unit

production and/or consumption.

There are then three general cases in the study of truck transportation from any one (manufacturing) site. In increasing propensity to generate numbers of trips, they are:

(1) All transportation provided by PMT (origin owned) or one trucking company.

(2) Transportation divided amongst trucking companies, with customers in close proximity tending to be served by one company.

(3) Transportation provided by the customers (customer PMT).

Naturally there are variations on these three basic types of transportation supply, but they will serve as illustrative cases subject to modification in specific instances.

The remainder of the chapter falls into two parts: first the bases of location theory are reviewed with the intention of identifying the consequences for intra-urban freight transport of point-pattern analysis. It is concluded that the greatest promise at present lies in some form of industrial linkage research. Second, the variables which appear to be most useful in explaining linkage intensity are exposed through a discussion of industrial structure and the institutions which facilitate the marketing of commodities.

Industrial Location and Transportation Demand

Clearly the locations of points of transportation demand and supply have a strong influence on trip distribution. They will not be the sole determining factor because of the probability of a large number of multiple pick up and delivery trips and consequent indirect vehicle routings between origins and destinations. It is less obvious, at least conceptually, that the location of economic activity necessarily has a causal influence on trip generation rates; rather, certain attributes of location appear to be associated with different propensities to generate and attract commercial vehicle movements.

Vernon discussed a wide variety of factors contributing towards the decentralization of urban manufacturing activity: space requirements, taxes, labour costs, and traffic congestion, for example. He noted that the smaller firm "usually needs the fractional use of transportation facilities" (LTL movements) and can obtain better LTL service in the core. If this is the case, it would be argued here that the firm's size, and thus demand for LTL transportation, "causes" a central location. This is significantly different from concluding that a central location causes a demand for LTL transport, since Vernon also observes that fractional transportation and service facilities are now available over a wider area, and do not provide as great a reason for retaining a central core location.[11] In other words, the spatial attributes of the urban transportation system allow a much greater flexibility in the distribution of transport activity than the capacity attributes allow in the volume of activity. This is further borne out by Vernon's observation that the shift in location to the urban periphery by wholesalers (with stocks) and the increasing insistence of central city retailers on LTL shipments, because of their desire to minimize the use of increasingly high cost space for stocks, will cause an apparent increase in radial transportation but not a shift to truck load deliveries.[12]

It is difficult to even partially derive a theory of transportation demand from location theory for two reasons: First, as observed above, there is only weak empirical evidence that the demand for truck transportation (numbers of movements) is influenced by location per se within urban areas; secondly transportation transpo[illegible] costs in some form are a determinant of activity location. An example from passenger transport may be appropriate: family units with similar socio-economic characteristics tend to have similar trip making profiles, especially if their residential locations are correspondingly similar. However, even where otherwise similar families have markedly

---

[11] Vernon, R. "Production and Distribution in the Large Metropolis", Annals of the American Academy of Political and Social Science, 3,4 (1957), 15-29.

[12] Ibid., 29.

different residential locations, for reasons not explained either by location/rent theory or statistical association with common variables (income, age family size, occupation), the distribution of trips will be significantly different but the volume of trip-making may not.

All that is intended at this juncture is to indicate some of the aspects of recent location theoretic research which may in the future contribute to models of commercial vehicle transport demand. Of the two fundamental branches of point agglomeration theory - industrial location and central place theory - we are concerned only with the former. This is not to say that theories of areal markets cannot be related to transport demand, but only that industrial location theory appears to afford greater opportunities since it traditionally and explicitly embodies transport costs.

Neo-Weberian analysis has attempted to improve on the original formulation of industrial location theory by relaxing the assumption that the maximum profit location for the firm is equivalent to a minimum transport cost location. Wood suggests two groups of criticism.[13]

(1) The principles of "economic man" and perfect competition ignore the varied structure, goals and controls of industrial organization.

(2) Transport costs are a factor of declining

---

[13] Wood, P.A., "Industrial Location and Linkage", Area, 2 (1969), 23-9.

importance in industrial activity and are thus no longer vital in making locational decisions.

The first criticism has been approached from several viewpoints. Weber recognized agglomeration economies, but Hoover and later Isard redefined them and distinguished between economies of scale, localization, and urbanization.[14] Greenhut has shown that there cannot be perfect competition over space; local monopolies theoretically always exist.[15] Since there is therefore a limit imposed on the market area of the firm by other firms, the location decisions of these other firms must be taken into account. In other words, the location problem is a general equilibrium problem which takes into account the simultaneous decisions of interdependent and/or competing firms. Hopkins has recently made this "firm vs. industry" distinction:

> "The classical procedure begins with the determination of the least cost transportation site and the construction of isodapanes through the surrounding area. The optimum site would deviate from the minimum transportation cost site if relative labour or agglomeration cost differentials at other sites were lower than the transportation cost differentials as specified

---

[14] Hoover, E.M., Location Theory and the Shoe and Leather Industries (Cambridge, Mass: Harvard University Press, 1937), Harvard Economic Studies No. 55, 89-93.

Isard, W., Methods of Regional Science (Cambridge, Mass.: M.I.T. Press, 2nd ed. 1971), 404-5.

[15] Greenhut, M.L., Microeconomics and the Space Economy (Chicago: Scott Foresman, 1963).

by the location's isodapane.

> Isodapanes, while reflecting transportation cost differentials between regions, are not suitable for use as a transportation variable in a regression equation. They are specified by the optimal site for one plant of a specified size, while the location model must simultaneously determine the change or level of employment of all plants...."[16]

Webber summarizes the problem thus:

> "Interdependence (or monopolistic competition), variations of cost with scale, changes in input mix with scale and location, and changes in optimum location with laterations in scale have all remained largely outside Weberian analysis."[17]

Alonso, while observing that optimum locations for individual firms vary with the factor mix, economies of scale, the structure of demand, pricing policies, the firm's objectives, etc., also noted that neo-classical industrial location theory is peculiarly unsuitable when applied within urban areas where the competition for <u>space</u> adds a new dimension to the location problem.[18] Given the importance of rent and transport cost gradients in urban

---

[16]Hopkins, F. E. "Transportation Cost and Industrial Location: An Analysis of the Household Furniture Industry", <u>Journal of Regional Science</u>, 12, 2 (1972), 261-277.

[17]Webber, M. J., <u>Impact of Uncertainty on Location</u> (Cambridge, Mass.: M.I.T. Press, 1972), 22.

[18]Alonso, W. <u>Location and Land Use</u> (Cambridge, Mass.: Harvard University Press 1964).
Alonso, W. "A Reformulation of Classical Location Theory and Its Relation to Rent Theory", <u>Papers and Proceedings of the Regional Science Association</u>, 19 (1967), 23-44.

residential location theory, it is perhaps surprising that Alonso's hypotheses have not received more attention. However, Sakashita has pointed out the difficulties dealing with the infinite heterogeneity of land as an economic good, and both Alonso and Sakashita seem to appreciate the difficulties of making rent and transport costs complementary through the use of "bid-price curves", which are analogous to isodapanes.[19] It seems, therefore, that this branch of location theory for which Alonso is most responsible does not at present generate much hope that it will contribute to our further understanding of the demand for commodity transport in urban areas through analysis of the factors affecting location; at least, the fundamental hypotheses go untested.

Empirical evidence suggests that economies of agglomeration are important to plants clustering at and within urban areas. Two closely related types of economy may be loosely defined:

(1) Localization economies, in which firms producing similar or complementary products benefit from locating in proximity to a common market, pool of skilled labour, or special services.[20]

---

[19] Sakashita, N., "Production Function, Demand Function and Location Theory of the Firm", Papers and Proceedings of the Regional Science Association, 20 (1968), 109-122.

[20] Localization economies have been referred to as quasi-integration, involving sub-contracting, joint research, close cooperation in production, and joint utilization of

(2) Urbanization economies, in which unlike firms cluster together to take advantage of a wider range of urban services than those dealt with under localization economies.

The key point here is that evidence of one plant's links to other activities and plants may also be regarded as surrogates for past and existing location forces. While not all of these forces will appear as commodity movements, many will. For example, the efficient movement of information and people in the day-to-day interaction between the plant and other sites may be important to the plant's operation but hardly critical to its location. Urban movement systems provide more flexible and efficient transport opportunities for people and information than they do for the movement of commodities. The reverse of this argument is probably true for office activites; some intermediate position may hold for retailing activities. Goddard, in his study of office locations in central London, pursued the above argument to its logical conclusion and assumed that the spatial association of different types of office activity implied a need for physical proximity, possibly because of "economic linkages" but also due to historical inertia and a common desire for prestige locations.[21] The

---

capacity. See: Houssiaux, J., "Quelques Expériences Récentes de Quesi-Integration," Revué Economique, 6 (Nov. 1959), 838-868.

[21]Goddard, J., "Multivariate Analysis of Office Location Patterns in the City Centre: A London Example", Regional Studies, 2 (1968), 69-85.

study of physical proximity and interdependence of urban activities is not new. Ratcliff observed the extent to which different types of establishment occurred in blocks and used an index of concentration to measure the tendency towards location attraction, or "self-affinities", among establishments of the same type.[22] Rannells examined the relative concentration, dispersion, and proximity of establishments in the Philadelphia business district.[23] However, the analysis of _industrial_ linkages in urban areas is a recent phenomenom. Townroe attempted a typology of linkages based on agglomeration factors, although it is difficult to see how his fourth and new class, transfer economies, or the savings in transport costs to each firm as a result of locating adjacent to one another, are anything other than a special type of localization economy.[24] Townroe did point out the problems, possibilities, and hopes of industrial linkages research:

> "Research at the moment can hope merely to a better understanding of individual cases rather than a comprehensive conclusion or a model that would provide

---

[22] Ratcliff, R. U., _The Problem of Retail Site Selection_. (Ann Arbor, Michigan: Michigan Business Studies, 9, No. 1, Bureau of Business Administration, University of Michigan, 1939).

[23] Rannels, J., _The Core of The City_ (New York: Columbia University Press, 1956).

[24] Townroe, P.M., "Industrial Linkage, Agglomeration, and External Economies", _Journal of the Town Planning Institute_, 56, 1 (Jan., 1970), 18-20.

> easy guidance to location policy-making....
>
> ....A possible future source of data may be the goods vehicle surveys of area transportation studies...
>
> ....There are also implications to be drawn from linkage patterns for transport planning policy. If the form of linkage is changing so that links need not be so frequent or can be maintained without travel between firms, the need for good transport routes between new locations and markets and suppliers is not so important. Alternatively, if links are found to be important in economic terms, transport connections between the selected growth points and existing centres may be developed as a deliberate aid to growth, rather than providing these connections only when existing routes become so over loaded as to force new construction."

Papers by Wood and Smith demonstrate the polarity of viewpoints on industrial linkage research. Wood not only provides a comprehensive literature survey and classification of types of linkage, he also rejects Weberian analysis in favour of an approach that is "primarily concerned with the 'social' relationships that....plants enjoy with other organizations". Significantly for this thesis, Wood recommends a categorization of plants according to their position within a chain of production (assembly) component, processing, or sub-contracting), their organization status, or their ownership background.[25] Smith's reply convincingly argues that the industrial linkage approach is not in itself methodologically distinct from Weberian analysis since both

---

[25] Wood, P.A., loc.cit.

are concerned with the effect of physical proximity on input costs.[26] The problem is therefore one of measurement rather than method: Wood considers locational factors which are less tangible than those traditionally considered as variables, but which are not of themselves intrinsically differend in their behaviour and effects. Instead of pursuing Wood's potentially complex formulation, Smith proposes a delineation of the spatial margins of profitability, within which all locations offer some profit and "behavioural" or "social" considerations may dominate the locational decision. Unfortunately, as Taylor points out, the spatial margin is so wide that from the practical, analytical standpoint we are forced again to solving the problem of bridging the gap between theory (with its fairly simplistic structure) and empirical observation (with its complexity of findings).[27]

In conclusion to this discussion of some aspects of industrial location research, it appears that the identification of linkage factors will assist urban goods movement studies if a particular type of linkage can be identified with a corresponding type of transport demand. Location theory, like transportation planning, is increasingly taking behavioural factors into account. Transport costs, for example, are perceived as becoming relatively less important

---

[26] Smith, D. M., "On Throwing out Weber with the Bathwater: A Note on Industrial Location and Linkage", Area, 1 (1970), 15-18.

[27] Taylor, M.J., "Location Decisions of Small Firms", Area, 2 (1970), 51-54.

in locational decisions by most firms. The varied structures and goals of industrial organisations, and the effect of uncertainty and risk on firm behaviour, are more promising areas for research.[28] The main short-term hope for contributions from industrial and commercial location theory to intra-urban freight transport demand analysis is that changes in location will be found to be associated with changes in the nature and intensity of inter-establishment linkages. In other words, if a comprehensive model of urban economic activity was to be built, two sub-models - one of industrial location and another of commodity and commercial vehicle flows - could probably be linked based on empirical rather than theoretical evidence.

Industrial Structure and Physical Distribution

While it does not yet seem possible to reason implications for urban transport demand from industrial location theory, there is some evidence that the analysis of linkages between firms will have greater payoffs. This is pursued in the following discussion of industrial structure and physical distribution, within which fields of research the behaviour of firms has traditionally been important. First, a note explaining that this section is

---

[28] Greenhut, M. L., A Theory of the Firm in Economic Space (New York: Meredith Corporation, 1970), 7-43.

Webber, M. J., Impact of Uncertainty on Location (Cambridge, Mass.: M.I.T. Press, 1972).

better and more appropriately described as theory development rather than model building.

For a variety of reasons, we cannot hope to develop simple regression models between employment and truck trips with any confidence unless we are aware of the complete technological and logistic structure into which these two variables fit. However, against this we need to weigh the requirement of theory development that there be no temporal or spatial restrictions on the class of phenomena which may be explained by considering a wide range of variables. In this context, Lowry's distinction between a theory and a model is useful: the theorist is

> "ordinarily content to specify only the conceptual significance of his variables and the general form of their functional interrelationships. The virtuosity of the theorist lies in rigorous logical derivation of interesting and empirically relevant propositions from the most parsimonious set of postulates. The model builderg....is concerned with the application of theories to a concrete case. He is constrained by considerations of cost, of data availability and accuracy....His model is likely to reflect its theoretical origins only in oblique and approximate ways."[29]

The role of assumptions is important: they economize the description of a theory, they facilitate model testing, and help specify the conditions under which the theory is expected to be valid. The most important assumption in the proposed marketing model is that economic

---

[29]Lowry, I.S., "A Short Course in Model Design", Journal of the American Institute of Planners, 31 (1965), 160.

behaviour is the result of rational decision-making. However, in model testing, the conventional practices of individual units in the economy are accepted, and efforts to force them into a system of consistency are less than strictly required by theory. This is what Artle has termed "decentralized description" as opposed to centralized description in which "all doubtful and conventional questions on evaluations, classification, time element, etc., are decided centrally...within a general and consistent framework".[30] The adoption of decentralized description allows broad generalizations in theory development in the expectation of refinements during specific model testing.

Before discussing types of distribution channels and firm behaviour within channels, some basic terms may be defined.[31]

Industrial structure can be defined in terms of a wide range of factors: the number of buyers and sellers of a commodity or class of commodities, the spatial distribution of supply and demand, difficulties of entry into the market, the type and degree of horizontal or vertical integration, and characteristics of the product and product differentiation. They have behavioural consequences:

---

[30] Artle, R. The Structure of the Stockholm Economy (Ithaca, N.Y.: Cornell University Press, 1965), 15.

[31] These definitions are adapted from a variety of texts, especially Revzan, D. A., A Geography of Marketing: Integrative Statement (Berkeley: University of California, School of Business Administration, 1968).

conduct, the behaviour of firms under different market structures, especially the degree and type of inter-firm competition, and performance, which relates to profit levels, growth rate, innovation, progressiveness, and the utilization of capacity. The firms in any one industrial activity system comprise the market place for the appropriate set of commodities; industrial structure is synonymous with market structure in many texts, although the convention here will be to restrict the former term to descriptions of manufacturing activites while market structure will refer to the agencies through which the product is distributed to its ultimate market - the point of final consumption. Marketing refers to all the activities associated with this process of changing the time and place utility of commodities: the setting of prices, decisions over what to buy or sell - and when, where and how. Physical distribution, the act of moving commodities between their originating site and points of demand, is part of the marketing process, although large firms frequently distinguish between marketing and physical distribution functions within their organizational structure. One can imagine a set of demands for commodities at a point of their final consumption being met by various industrial activity systems. Numerous agencies - wholesalers, retailers, transportation companies, etc. - exist to facilitate the movement of sets of commodities through time and space. For any one set of commodities, or shipment, there exist alternative distribution channels.

The channel analogy describes the institutions and/or activities through which the shipment "flows". In their significance for transportation demands and trip generation in urban areas, the concepts of industrial structure and channels of distribution can be shown to be inextricably linked. Their structures have joint effects on firm and plant behaviour and will be analysed as such.

Distribution channels are a manifestation of producer-consumer linkages and may be analysed through several approaches.

(1) Abstract channels: an explanation of channel existence, and thereby structure and function, may be derived from microeconomic theory. The Converse and Jones definition of distribution embodies this idea: "marketing distribution includes those activities which create place, time, and possession utilities".[32] Bucklin and Alderson have developed conceptual frameworks and the bases of theory using this approach. Bucklin combined a typology of marketing functions and the theory of the firm, while Alderson used a similar but dynamic approach by showing the relationship between increasing specialization, centralized exchange, the creation of time and place utility, and the routinization of transactions in the development of distribution channels. Through flow-charts of the movement

---

[32]Converse, P. D. and F. M. Jones. Introduction to Marketing (New York: Prentice-Hall, 1948), 4.

of commodities in primitive economies and different development stages of the market economy, Alderson was able to show the role of intermediaries in the process of distributing goods from producer to consumer.[33] The abstract approach, particularly Alderson's, may in the future be usefully associated with changes in transportation network structures and the interregional demand for goods.

(2) The structural approach: this is defined as: "a channel of distribution may be thought of as the combination and sequencies of agencies through which one or more of the marketing flows move".[34] It is closely linked with;

(3) The functional approach: the concern of functional analysis is identification of the distinct operations in the creation of time, place and possession utility. The agencies performing these functions may be transitory but their functions are assumed to be inherent in the marketing of every good.

The distinction between these two approaches, structural and functional, lies in the fact that one component of the structure - an agency or institution, i.e. firm - may perform more than one function. It may forward goods

---

[33]Bucklin, L. P., "The Economic Structure of Channels of Distribution," Marketing: A Maturing Discipline, ed. M.L. Bell (Chicago: American Marketing Association, 1960).

Alderson, W., "Factors Governing the Development of Marketing Channels," Marketing Channels for Manufactured Products, ed. R. M. Clewett, (Homewood: R. D. Irwin, 1954).

[34]Vaile, R. S., E. T. Grether, R. Cox, Marketing in the American Economy (New York: Ronald Press, 1952) 121.

to ultimate consumers on both a retail and wholesale basis for example. The two approaches are only identical to the extent that individual sites of commercial and industrial activity perform singular functions. It is useful to combine the two approaches into the systems approach. Systems analysis suggests at once a concern with a set of objects and relationships between those objects. Thus we define the set as comprising those institutions through which the commodity moves in the market place, and the relationships as the functions performed by the members of the set.[35]

There are several other attributes of distribution, not least of which are non-physical flows. Associated with the movement of any commodity are channels of ownership, payment, and information. These are frequently very important: the existence of the wholesaler intervening between manufacturer and retailer may be predicated on his ability to act as a source of information and credit which is lacking elsewhere in the channel.

Other characteristics of distribution channel structure and function are the differing degrees of risk-bearing and power among the channel's participants. The question of power and risk-bearing is discussed briefly here, not because it is essential to the development of the

---

[35] Stern, L.W. and J.W. Brown, "Distribution Channels: A Social System Approach," Distribution Channels: Behavioural Dimensions, ed. L.W. Stern, (Boston: Houghton Mifflin, 1969), 6 - 19.

theory, but because further research, especially in the prediction of future trip generation levels and distribution patterns, will have to take explicit account of the effect of changing distribution channel power structures on transportation demand. Power in the market or distribution channel may be defined as "the ability of a market participant or group of participants to influence price, quantity and the nature of the product in the market place".[36] Since the struggle for power pervades the whole market place, the outcome through time obviously has important implications for the development of different industrial and distribution channel structures which in turn are reflected in changing patterns and levels of transportation demand. "Essentially the struggle is for control over the marketing machinery - over who shall perform the marketing functions".[37] One of the consequencies of changing power structures is that the components of distribution channel structure and activity systems change over time, while the greater the cooperation and tacit recognition of market shares or functions, the greater the probability that the channel's structure will remain stable over time. Power in the channel may be the

[36] Shepherd, W. G., Market Power and Economic Welfare (New York: Random House, 1970), 33.

[37] Engle, N. H., "The Struggle for Marketing Control," Problems of Small Business, Monograph 17, The Investigation of Concentration of Economic Power, U. S. Temporary National Economic Commission, (Washington: U. S. Government Printing Office, 1941), 159.

result of many factors: control over financing, raw materials, the final marketing of the product, or the ownership of the product. The last mentioned is especially interesting in its implications for transportation demand. Product ownership may be either a strength or a liability for a firm. Those firms which regard ownership as a liability will tend to postpone ownership and storage of goods until they are ready to use or re-sell them.

Postponement of purchase is a device for shifting the risk of owning goods between individual institutions. There are transportation economies to be gained through postponing the differentiation of a commodity within the channel of distribution. By differentiation we mean the sorting of the bulk commodity into smaller lots both in terms of the form and identity of the product and also inventory location. The economies arise out of those associated with bulk transportation, handling, and packaging. Against this must be measured the costs of storage - the costs, and risks, of owning large quantities of the commodity at any one point in time. Postponement of purchase occurs therefore when the costs of owning the commodities exceed those of transporting them. Under these conditions, actual purchase will be put off until time of use and this circumstance might be associated with small shipment sizes and frequent purchases.

The converse of postponement is speculation: that is, changes in the form of goods and their movement to forward inventories at the earliest possible moment in the channel. In this case intermediaries in the channel between producer and consumer absorb the risks of ownership by taking on the large inventories usually necessary at some point in the channel. They attempt to offset this cost through savings in transportation (the shipment of large lots), possibly at less frequent intervals than would be the case under conditions of postponement.[38]

Specific cases of postponement, speculation and different power structures will be observed later in a case study. It should be observed at the moment, however, that these aspects of marketing and distribution channel research are relatively undeveloped even within their own discipline, whereas the literature on structure and function is voluminous.[39] The purpose of this thesis is not to explain the circumstances under which one or another type of industrial

---

[38] Alderson, W., "Marketing Efficiency and the Principle of Postponement," Cost and Profit Outlook, 3, 4 (1950).

Bucklin, L.P., A Theory of Distribution Channel Structure (Berkeley: University of California, Institute of Business and Economic Research, 1966), Ch. 3.

______, "Postponement, Speculation, and the Structure of Distribution Channels," Journal of Marketing Research, 2 (1965), 26-31.

[39] The behavioural characteristics of channel participants are analysed in greater depth in the following:

Alderson, W. Marketing Behaviour and Executive Action (Homewood: R. D. Irwin), 1957.

______, Dynamic Marketing Behaviour (Homewood: R. D. Irwin, 1965) Chs. 10, 12, 13.

Mallen, B. E., "Conflict and Cooperation in Marketing Channels," Reflections on Progress in Marketing, ed. L.G. Smith (Chicago: American Marketing Association, 1964) 65-68.

or distribution channel structure may exist. Rather the concern here is to take structure and function as given and deduce the behaviour of firms under alternative systems. This structure-behaviour causation is similar to that of neoclassical analysis of allocation in which a variety of market shares are posited for the firm - negligible in perfect competition, small in monopolistic competition, moderate in oligopoly, and total in monopoly, and firm behaviour is deduced accordingly. The classification of channels adopted here is shown in Fig. 5. The two sub-classes of channel are:

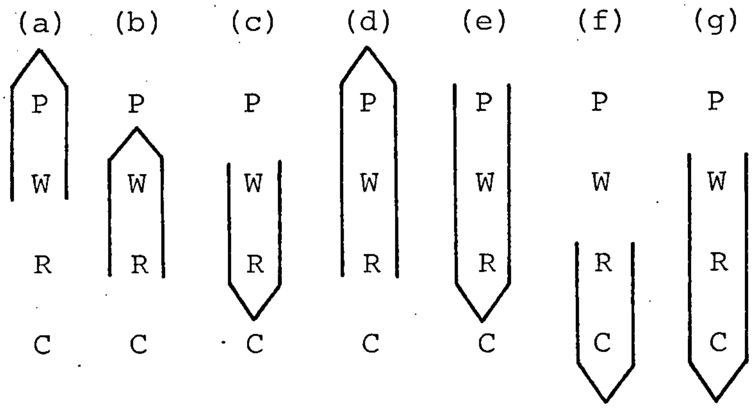
(a) Non-integrated: this type attributes independent behaviour to each of the channel participants. It requires a minimum of "behavioural" information in order to derive real examples of this type of channel.

(b) Integrated: the introduction of control relations within channels enables us to use the concepts of postponement and speculation. In urban areas, where the costs of transporting commodities tends to be low relative to the costs of storage, channels exhibiting <u>backward integration</u> (Types 2c, 2e, 2f, 2g) are likely to force the storage function onto an earlier channel participant by postponing purchases until time of "real" need. Similarly, where <u>forward integration</u> is the case (Types 2a, 2b, 2d) the source of channel control will probably cause subsequent channel participants to assume the storage function. In the latter case, speculation will probably result: in Type 2a, for example, the wholesaler may retain the manufacturer's

Figure 5 Distribution Channels

Type 1 Non-Integrated Channels

Type 2 Integrated Channels



P = Producer
W = Wholesaler
R = Retailer
C = Consumer (final user)

--Source

of ownership or control

--Direction

Source: partly adapted from Revzan, D.A. Wholesaling in Marketing Organisation (New York: Wiley, 1961) business by being able to assure him of a turnover of the product in large lots. To reach the retail market directly would cost the manufacturer substantially more than the savings possible by using the wholesaler. The difference between these costs and savings is a measure of the flexibility open to the wholesaler in speculating on future demand and price.

A complicating factor in this relatively simple classification is the degree of horizontal integration that might exist at any of the levels within channels. The possibilities of ownership, control, or collusion between producers, retailers, etc. can substantially alter the relationships shown in Fig. 5. In the example given above (type 2a), the flexibility open to the wholesaler might be substantially lessened if he has no alternative sources of the commodity due to collusion between local (oligopolistic) producers. Before examining alternative trip generation rates under different distribution channel structures, the concept of <u>sorting</u> and <u>economic order quantity</u> (EOQ) are mentioned as they help to integrate some of the previous discussion.

<u>Sorting</u> refers to the changing of a commodity's quantity and location in the physical flow. Marketing as a whole can be seen as the matching of supply and demand, part of which is the offering of correct assortments of the commodity. Sorting can be described according to the location at which it takes place:

(a) Inventory sort: changing the composition of shipments at one site.

(b) Transit sort: the addition or dropping of goods during shipment.

The place of sort in the channel is determined by the form and direction of channel integration. Sorting can be classified according to the process involved:[40]

(a) Sorting out: the division of some collection of different goods into sub-collections which better fit the needs of a distant market.

(b) Assorting: the construction of a set of several goods for some unifying purpose.

(c) Accumulation: the building of a large supply of similar goods for some unifying purpose.

(d) Allocation: the breaking down of a large supply of similar goods into smaller lots which better fit the needs of the market.

Economic order quantity (EOQ) is determined by a firm after the balancing of two costs: those of ordering (including transportation) and carrying (inventorying and storage.) The joint effects of these two costs are demonstrated by Bowersox, Smykay and LaLonde and are shown here in Fig. 6. Their illustration was derived from Bowman and

---

[40] Alderson, W., Marketing Behaviour and Executive Action (Homewood: R. D. Irwin, 1957), 199.

Figure 6

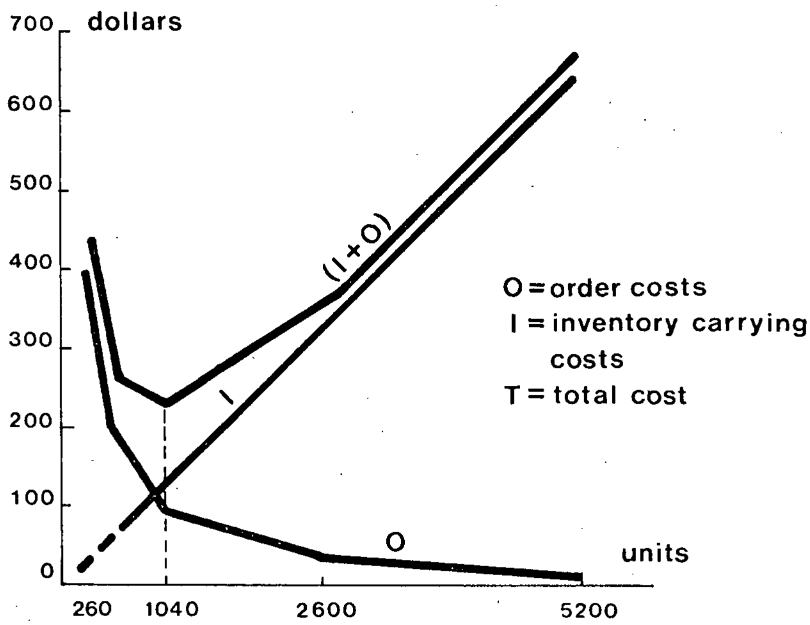
Assumptions:

carrying costs: $0.25 per unit
order costs: $ 20.00 per order
average inventory = 1/2 of order quantity
total sales: 5200 units per year

Tabular Method For Formulating EOQ

	number of orders				
	1	2	5	10	20
(1)size of order (units)	5200	2600	1040	520	260
(2)average inventory (units)	2600	1300	520	260	130
(3)carrying costs	$670	325	130	65	32.50
(4)order costs	$ 20	40	100	200	400.00
(5)total cost	$690	365	230	265	432.50

Graphic Method of Applying EOQ



source: Bowersox, Smykay, Lalonde. (1968)

id/hs

Fetter.[41]

An alternative method to the tabular and graphic methods in Fig. 6 is the calculation

$$EOQ = \sqrt{\frac{2\ a\ s}{c}}$$

where: a = ordering, transport costs

s = annual sales rate

c = inventory, interest costs

Summarizing this discussion of physical distribution channels, we can conclude that differences in channel structure and variations in channel behaviour has an effect upon the nature and intensity of inter-establishment linkages. It is useful to view an industrial structure as a <u>social system</u>, albeit constrained by economic relationships. The actors within the system - manufacturers, retailers, etc. - establish linkages with each other whose features reflect individual firm behaviour in the market place. <u>Speculation</u>, by wholesalers and retailers for example, may lead to the shipment of goods in infrequent large lots from manufacturers; <u>postponement</u> of purchase "until the last minute" should be associated with smaller shipments.

The concept of <u>economic order quantity</u> demonstrates how firms balance inventory with transport costs; the size

---

[41] Bowman, E.H. and R.B. Fetter, <u>Analysis for Production Management</u> (Homewood: R. D. Irwin, 1961), 269-276.
Bowersox, D. J., E. W. Smykay, and B. J. LaLonde, <u>Physical Distribution Management</u> (New York: MacMillan, 1968), 201-217.

of a shipment therefore is not a random variable, but has a magnitude which varies according to pre-determined costs. Recalling the analysis of truck transport supply, it might be expected that truck capacity is adjusted where possible to shipment size, which in turn results in different trip generation and attraction rates per unit volume shipped.

The type and location of sorting activity in the distribution channel may be, through a knowledge of channel control (and direction of integration), another source of explanation of trip generation rate variation.

Some of the concepts which have been introduced are now discussed in terms of their direct implications for the demand for truck movement.

Physical Distribution and Trip Generation

In most marketing texts, "the commodity approach" to the study of distribution channels is classified as a distinct alternative to the functional or structural approaches. This is not a very useful distinction, since all theoretical research on the subject must inevitably take a "commodity approach" when applied to real-world channels. However, the large number of studies on distribution channels actually used by firms and industries for different commodities is an additional source of descriptive empirical evidence for the understanding of the institutions involved in the movement of goods. It is difficult to associate type of good per se, that is its physical characteristics, and the selection of a particular distribution channel. A more important source of variation in distribution channel structure and trip generation rates is the role of the good in the production and distribution process. Initially goods may be divided into industrial and consumer goods.

(1) Industrial goods: this includes those products used in installation, as accessories, component parts, or raw materials for further processing. Several empirical studies of channels used for distributing industrial goods provide a priori evidence for expecting differing trip generation rates based on the market for the manufactured product. Initially we may identify six main types of channel open to the industrial goods producer (Fig. 7). Elling found that direct selling and shipment to the user was the most common pattern for all industrial goods, although Diamond, in a specific study of the channels for industrial machinery, equipment and supplies, found that factory-distributor-user channels were prevalent.[42] The circumstances under which one or the other are normally used relate to the structure and location of the industry and its market:

(a) The use of wholesaling institutions increases as the market area increases. All intermediaries in the industrial goods channel are "wholesalers"; their purpose is to reach a wide

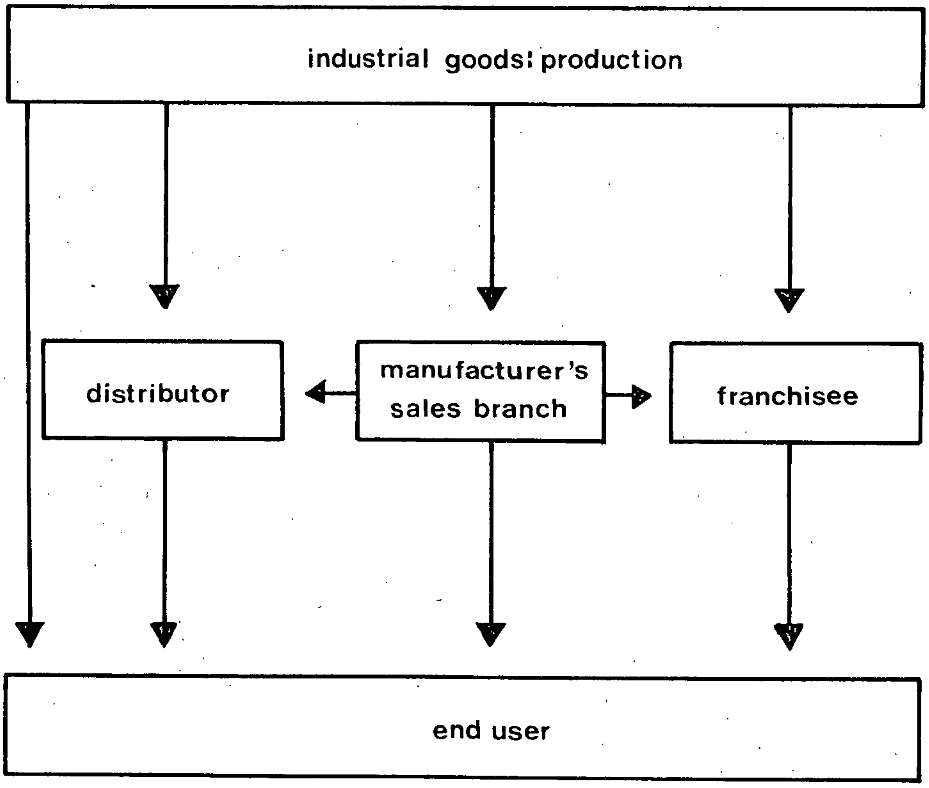
---

[42]Elling, K. A., Introduction to Modern Marketing (New York: Macmillan, 1969), 128-135.

Diamond, W. H., Distribution Channels for Industrial Goods (Columbus, Ohio: Bureau of Business Research, Ohio State University, 1963).

Figure 7:

Simplified Distribution Channels: Industrial Goods



id/hs

market and bridge the communications gap between producers and consumers. As the number of transactions between producer and market increase higher trip generation rates may be expected. The extent of the market (measured by average distance per unit shipped) should be non-linear in relation to truck trip generation rates because of economies of scale in transportation: especially important is the tendency to use rail traffic beyond a truck traffic hinterland. If the intermediary is producer-controlled (manufacturer's sales branch) we may, for reasons given earlier, expect even lower truck trip generation rates. If the market for the commodity is local, and the sorting process takes place at the production site because an intermediary is not used, the number of truck trips per unit time should be a function of the number and size of end-users. The trip generation rate in this case is adjusted according to who provides the transportation. If it is provided by the producer, then lower trip generation rates may occur due to the economies of scale in multiple-delivery shipments.

(b) Smaller producers and wholesalers have higher trip generation rates per employee than larger firms, under the assumption of constant labour coefficients in the production functions. There are a variety of reasons for expecting this. Small firms may have higher inventory costs per unit than large firms, resulting in lower EOQs and an increase in expenditures on transportation per unit relative to larger firms. Large firms tend to establish their own sales branches or control retail or wholesale outlets and thereby pass much of the sorting function on to other sites in the channel; this allows bulk shipments from the producing site. Large firms can frequently be identified as <u>export</u> (from the urban area) industries, shipping their products not only by non-highway transport but also producing for distinct regional markets. The latter encourages the establishment of regional sales branches, even for the local market, further lowering the trip generation rate. Small firms may exhibit greater variation in trips per employee because of their tendency to serve specific types of local market and perform specialized functions.

These generalizations about transport and marketing behaviour should not be interpreted as being without important exceptions. They show that marketing variables can intervene in any firm-size/transport demand explanation of trip generation rates. The greater the variation in marketing behaviour from industry to industry, the greater will be the dissimilarity in transport demand between firms equal in size but different in commodity produced. Detailed empirical analysis of different industries are necessary before we are able to confirm logical relationships between plant size, marketing behaviour, and transport demand.

(2) <u>Consumer Goods</u>: Consumer goods channels correspond to those shown earlier in Figure 5. They are characterized by various combinations of producer-wholesaler-retailer-consumer and normally use more intermediaries than those for industrial goods because of the greater diversity

in product supply and demand. Many sorting, lot size and product identity changes are frequently required to transform a product from the form in which it is initially produced to that in which it is ultimately consumed (by the individual). Where the number of changes required are least, higher trip generation rates may be expected at producers who serve local markets. The same principles governing industrial goods channel selection apply to consumer goods channels. Duncan observed that shipments were likely to be direct to retailers where the market was one of established, widespread demand, where the number of customers was large in relation to the territory covered, and the product constituted a substantial and essential part of the retailer's stock.[43]

A number of other characteristics of the product and its market influence channel selection and therefore trip generation rates. The more _perishable_ or _fragile_ the product, the greater the risk associated with ownership. This risk tends to minimize the amount of storage and handling the product can bear in the channel and encourages the use of direct producer-consumer channels. The _variability of demand through time_ is significant for some products: if product lines are subject to rapid changes in style and fashion, prompt delivery from producer to consumer may be

---

[43]Duncan, D. J., "Selecting a Channel of Distribution", _Marketing Channels for Manufactured Products_, ed. R. M. Clewett (Homewood: R. D. Irwin, 1954), 380.

required. In this case the number of intermediaries would have to be minimized. If either demand or supply is seasonal, however, future quantities required of the product in the channel may be anticipated, and storage of the product somewhere in the channel may occur. Ownership risks may be associated with new products; if they have difficulty in gaining acceptance by intermediaries they may be directly distributed to the consumer or retailer. Closely allied to this is the influence of the age of firms. Barloon has noted that in urban areas the newer industries tend to produce highly processed goods whose marketing requires short door-to-door delivery time, a high predictability of delivery, and no loss or damage.[44] Furthermore, one method open to new firms competing in an established market is to add time and place utility to the value of the product through fast and efficient distribution. Both these conditions imply the need for direct producer-to-user transportation.

So far we have assumed only one site (manufacturer, wholesaler, etc.) at each distinct level of distribution. The principle of minimum transactions shows how the number of interplant linkages may be reduced with the introduction of an intermediary between groups of

---

[44] Barloon, M. J., "Premium Transportation: A New Influence in Site Selection", Handling and Shipping, (1965), 45-47.

manufacturers and retailers (Fig. 8).[45] Manufacturing trip generation rates may be higher in model (a) than (b) in Figure 8. This will arise if, and only if, manufacturers are able to increase shipment sizes by serving one instead of five customers.

Several steps have been taken in this chapter towards a theory of urban commercial vehicle flows.

(1) The demand for truck transport varies closely with the demand for commodities, except where inter-city transport is concerned.

(2) The supply of truck transport can be expected to affect trip generation rates; the highest levels of trip-making exist where supply is privately and owned by "down-channel" institutions, retailers for example.

(3) The physical distribution behaviour of industries and commercial institutions influences the volume of truck trip demand. One eminently testable hypothesis is that direct producer-consumer distribution channels cause higher trip generation rates, especially if the consumer provides the transportation. The influence of other factors, such as product characteristics, risk associated with product

---

[45] Three principles justifying intermediaries:
The principle of minimum transactions: Fig. 10;
The principle of massed reserves: less goods are needed in inventory in the channel as a whole when intermediaries are used;
The principle of proximity: intermediaries give goods greater time and place utility locating close to the market.

See: Staudt, T.A. and D.A. Taylor, A Managerial Introduction to Marketing (Englewood Cliffs, N. J.: Prentice-Hall, 1965).

(a)

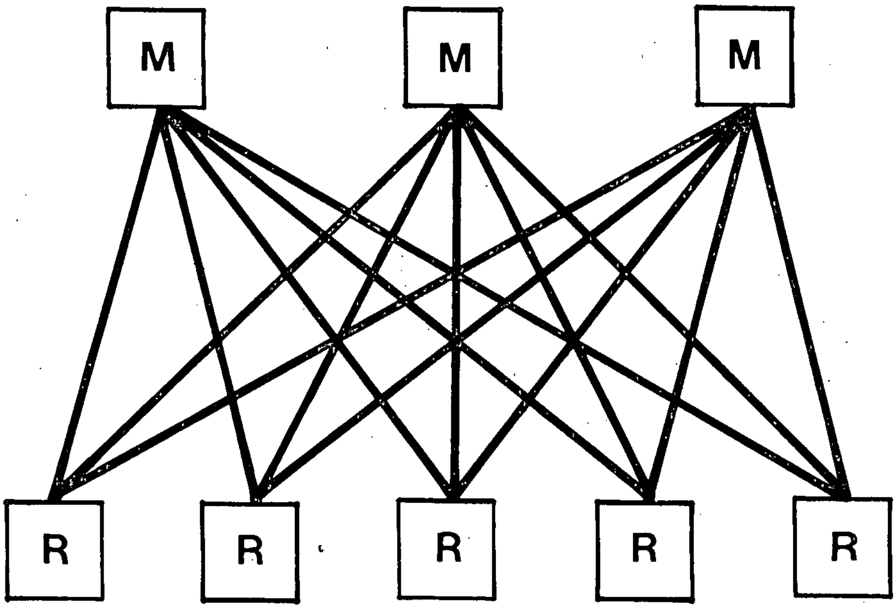
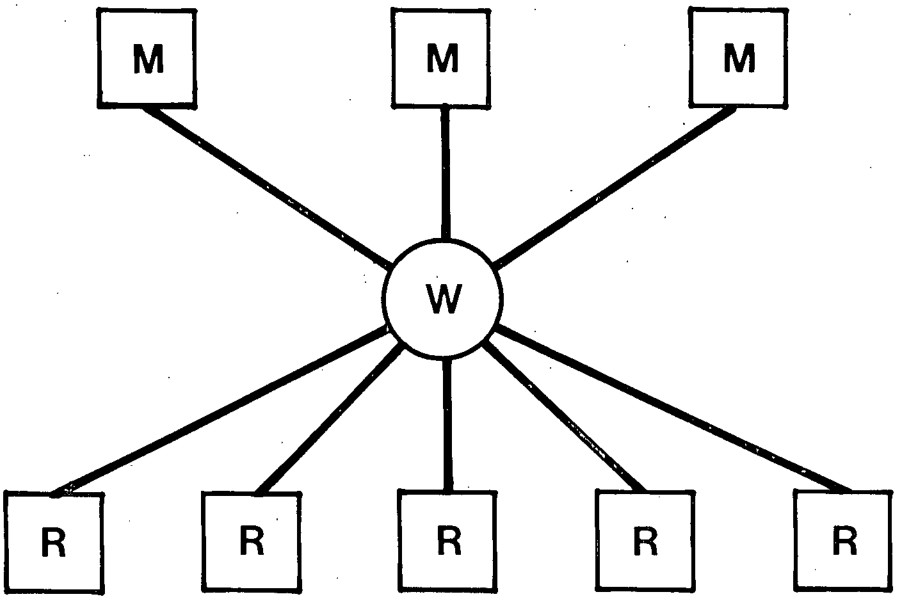


Figure 8: Principle of Minimum Transactions

(b)



id/hs

ownership, local distance to market, and physical characteristics of the product, may all be estimated qualitatively. However, their interdependence is such that statistical isolation of the relative effect of each will have to await extremely good data and the validation of the principle that physical distribution channel selection per se controls trip generation rates. It is this latter, and most important, hypothesis which is tested in the following case study.

CHAPTER V

THE SURVEY METHOD, PILOT SURVEY RESULTS, AND DATA ORGANIZATION

It has been shown (Chapters II and III) that not only are there deficiencies in the traditional approach to the analysis of urban transport demand, but that urban goods movement studies themselves are not building explanatory models of transportation. Chapter IV discussed a variety of effects which differences in distribution channel structure and behaviour could have on trip generation rates, and it was deduced that the most apparent cause of variations in trip-making potential were: the source of transport supply, the location of inventories in the distribution channel (and consequently shipment size), and the institutional structure of the distribution channel itself.

Unfortunately, no data were readily available to test the effects of channel structure and the behaviour of channel participants, so a completely new data base was created. The distribution channels for the local marketing of wood products, notably lumber, were selected for analysis. A survey of the shipping records of forty-three manufacturers of wood products generated the data for two tests: one of the approach used in previous truck movement studies which relates employment directly to transport demand, the other of an improved version which incorporates marketing and physical distribution variables. This chapter describes the data and survey procedure. Chapter VI tests the usual plant-size model of trip generation. The following chapter presents the marketing model and discusses the impact of firm behaviour and industry structure on truck movements. Chapter VIII reverses the analysis and uses the same survey data to analyze retail trip attraction rates.

The Survey Procedure

The wood products industry of Greater Vancouver was designated as the activity system to be analysed in a test of the relationships hypothesized in the previous chapter. This industry was selected because of its basic importance to the Greater Vancouver economy and the reasonable homogeneity of the physical characteristics of the products - mainly lumber and plywood - irrespective of their "location" within the distribution channel.

The complete wood products activity system comprises all those activities which produce, remanufacture, buy, sell, and consume wood products. Wood products include those commodities produced as a result of activities listed under Standard Industrial Classification (1970) codes 250, 260, and 270.[1] Such an activity system is a large complex

[1]See Appendix.

of hundreds of firms and products so diverse that a sampling problem is immediately apparent. A scan of industrial directory data reveals that the vast majority of the wood products firms are small, that is less than 20 employees. Anything less than a very large random sample would be unlikely to include the few large firms. As a result, the effects of numbers of employees per firm would be difficult to detect.

The term "wood products activity system" suggests rightly that the only criteria for the inclusion of any firm is that wood be a principal component of that firm's input and output materials. For these reasons, the activity system was stratified into sub-systems based on process: mill, remanufacturing processes, construction, furniture manufacturing, wholesale, and retail. This classification should ideally correspond to institutions which comprise a logically structured set of alternative distribution channels for wood products. Mill processes were selected for analysis because of the wide range of size variation among firms, the expectation that variations in productivity would be low, and because of the central role of the mill in the production and distribution of wood immediately after the conversion of timber into lumber and plywood.

Forty three mills were identified: twenty sawmills, eight plywood mills, four paper mills, and eleven miscellaneous mills. The sawmills and plywood mills comprise the complete population of such activities in the Vancouver area;

the paper mills and miscellaneous plants were included in order to examine the goods movement requirements of a wider range of firms. The paper mills include the two major paper producers of the region and two of the several paper conventors, i.e. a producer of fine paper and a manufacturer of boxes. The "miscellaneous" mills all re-manufacture lumber or plywood; they were selected arbitarily to include a wide range of plant sizes and a wide variety of mills processes.[2] The size and location of all the plants surveyed is shown in Figure 9.

The marketing model proposed does have peculiar data requirements: we need to know not only the number of truck trips generated by industrial and commercial sites but also the frequency of trip-making associated with different activities at those trips' destinations. We also need to know where control of the channel lies, who provides the transportation, and how demand for the commodity varies over time. These are stringent data requirements, and such detail is not available in any previous studies of commercial vehicle movement.[3] Consequently raw data had to be collected specifically for this research.

---

[2] Miscellaneous includes the following activities: pole and piling plant, shingle mill, treating and preserving lumber and plywood, laminated beam plant, cedar siding mill, millwork plants (3), custom-cut lumber mill (for construction sites only), pallet manufacturer, and a manufacturer's sales branch. The last is not a manufacturing site, but the significance of its inclusion will be appreciated later.

[3] See Chapter III, which discussed recent research.

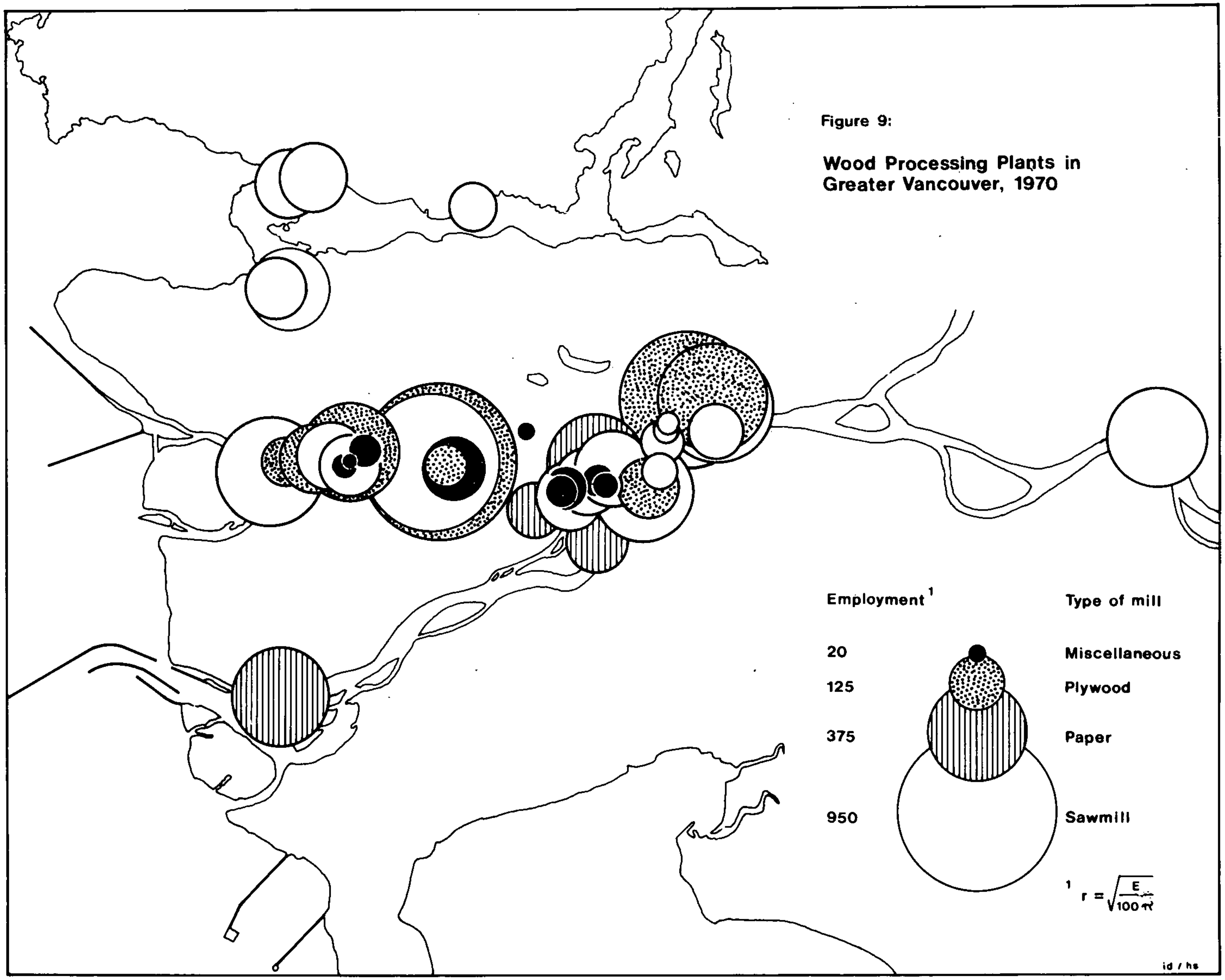


Figure 9:

Wood Processing Plants in Greater Vancouver, 1970

The types of data needed from each mill fall into two categories:

(1) Within-site data, such as employment size, access to different transport modes, and volume of shipments over time. These data must be collected by direct interviews with company management.

(2) Truck movement data, which may be obtained by either interviewing drivers as they leave the plant, or consulting mill shipping records. Previous surveys of urban commodity and truck flows have used the former method, although usually the information gained has been only a simple count of vehicles which would obviously be inadequate here since no data are thereby generated on the destination of shipments. The advantage of interviewing drivers is the accuracy of data collected, but this is far outweighed by the disadvantages: such a method is extremely time-consuming and labour-intensive, and the disruption to mill or trucking company operations would probably be intolerable. Consequently the alternative method, a survey of mill shipping records, was selected.

A pilot survey of four mills of various sizes and functions, was undertaken in order to become familiar with the mills' procedure for recording shipping activities and to expose any potential problems with data definition and collection.[4]

---

[4]The comments on data requirements, definition, and collection problems apply equally well to all commercial sites.

The pilot survey was conducted, therefore, by means of personal visits to each of the four mills in order to ascertain the availability of the following data:

(1) Number of employees at the site.

(2) A count of individual shipments over time, including shipment size, vehicle load factors, and shipment destination.

With the experience thus gained, a complete survey of the forty-three mills was undertaken by personal visits of this writer to the mills concerned. The data collected were then organized into a manageable form so that statistical analysis could be carried out by computer.

Results of the Pilot Survey

The pilot survey of the four mills revealed data collection and definition problems with four items:

(a) Employment

(b) Vehicle load factors

(c) Trip destinations

(d) The period of time for which truck movement activity should be recorded.

(a) Firms use a variety of methods to arrive at "number of employees". "On payroll" includes those persons who may be absent for a variety of reasons yet still receive pay. This causes a real distortion of "employment size" during the summer (holiday) months. The on-payroll definition frequently includes off-site employees, especially salesmen, drivers, and managerial personnel who locate at a head office. The lack of consistency between firms using this definition implies that it should not be used. However, it is apparent that any survey question which asks for "employment" will usually obtain the on-payroll definition unless specified otherwise.

"Man-hours worked": this definition of employment is probably ideal in that it takes direct account of work-stoppages, shiftchanges, and, in conjunction with measures of material output or its value, could be used to analyze productivity. As firm size decreases, however, records of man-hours worked appear to be less available. In an industry characterized by small firms, the widespread utility of such information may be doubted.

Average number of production workers was the definition used. It refers to the number of workers on payroll after the following have been subtracted: employees on holiday but still paid; managerial, clerical, and supervisory staff. It includes maintenance workers employed on the site because if we assume that the number of man-hours required for service and repair is directly proportional to the size of the plant (given constant and homogeneous technology) then larger plants will distinquish maintenance as a distinct occupation whereas in small plants the maintenance function will be performed by employees whose primary task is "production".

(b) The load factor on each trip could not be ascertained from shipping records, because although the size of shipment was well recorded no information was generally available on the capacity of the vehicle associated with each shipment.

(c) The destination of trips was not always recorded; in the case of office wholesalers, for example, title is taken to the goods but not physical possession - the goods may be delivered directly to a construction site. However, the wholesaler's name will appear on the invoice. Such cases were checked as far as possible by comparing invoices (the firm's record for billing the customer) with delivery slips (the truck driver's record of having made a delivery). Each delivery slip records the invoice number, so by cross-checking it is possible to find quantity shipped from the invoice and destination of shipment from the delivery slip.

(d) The whole question of time had to be carefully considered. The pilot study showed that diurnal, seasonal, monthly and annual variations in the supply and demand pattern for lumber are substantial. Previous trip generation studies have used the day or at the most the week over which to count vehicular movement. The use of small time units is probably due to their use in passenger transportation studies. However, passenger movement is largely scheduled and routine so regularities can be detected using time periods of one day or less. Much intra-urban truck movement is apparently random over short time periods, or is at least the result of such a complex range of factors that explanation of variation over short time periods would be extremely difficult. Day-to-day variation in trip generation rates was found to be quite substantial, greater in fact than week-to-week variation. As will be seen later, there is a growing tendency for the inventory function to be forced back onto the manufacturer in the sawmill-based activity system. This means that shipments are made to retailers and construction sites at the time of their immediate need. Retailers tend to stock towards the end of the week, construction sites towards the beginning. Taking any one day within the week will distort the <u>average</u> situation. Average is stressed because employment does not vary with short-term demand - rather it changes with anticipated longer-term demand and the <u>supply</u> of logs. Billing policies affect week-to-week variation in local demand: a common condition of sale is payment by the 15th of the following month. This causes demand to be concentrated at the beginning of months, thus allowing a maximum of 45 days before payment falls due. In an industry characterized by the importance of cash flow, this might be expected to have an important effect of trip generation rates. Because of the great variation in daily and weekly levels of demand for the product, and the lack of parallel variation in employment, <u>one month</u> was selected as the basic time unit.

This is encouraged by the fact that aggregate industry statistics are available on a monthly basis, and the individual shipment totals could be checked against the firm's own record of total monthly shipments. As a result it was possible to estimate the percentage of total shipments destined for the local market.

It became obvious, even in the pilot survey, that the same month could not be surveyed for each firm for reasons of data availability. It was also undesirable to specify one particular month as much as possible because that month would be distorted by temporary shutdowns for some of the firms. Some months - those whose shipment levels were affected by disruptions in transportation services (tow-boat labour disputes, for example) - could be expected to give unrealistic relationships between employment and shipments. The month selected for each firm had to meeting the following criteria: it should be in 1970, it should be as close to annual average shipment volume as possible, and it should be as far removed as possible from anticipated or recent labour disputes.

As a result of the pilot survey, data requirements were finally defined as:

(1) Average production and maintenance workers, monthly for 1970.

(2) Total production and shipments for each month.

(3) Truck shipments per day for one month, including destination and quantity for each shipment.

These data were collected, during Spring 1971, for all forty-three plants. In each case, the survey followed the following procedure:

(1) A letter, followed by personal visit, to senior firm executives in order to explain the purpose of the study and outline data requirements. A 100% success rate was achieved in soliciting cooperation from management.

(2) A visit to, and often a tour of, each mill so as to become familiar with its function and organization.

(3) A survey, which took from a few hours to over a week, of the mills' employment, production and shipping, and daily truck activity records.

Shipment Classification and Organization

Much of the data which were collected from the twenty sawmills are shown in summary form in Table 3. A distinction between local and non-local trips can be recognized. The reason for this is that truck movements from an industrial site may be classified into several types:

(1) Principal commodity movement: this includes all truck trips whose purpose is to move the main product or product group produced by the site to a final or intermediate destination. It can be subdivided into:

(a) Local shipments: the adjacent institution in the physical distribution channel is located within the greater urban region and no mode transfer is likely.

Table 3

VANCOUVER SURVEY: EMPLOYMENT, PRODUCTION, TRUCK TRIP DATA

Sawmill Number	MEAN ANNUAL EMPLOYMENT 1970		ANNUAL LUMBER PRODUCTION (1000 FBM) 1970	TOTAL TRUCK TRIPS PER WEEK	
	PRODUCTION WORKERS	OFFICE AND SALES EMP.		LOCAL	NON-LOCAL AND EXPORT (TO DOCK)
1	221.0	31	10840.1	26.05	1.32
2	50.7	7	1269.5	28.25	3.75
3	422.0	45	6291.1	38.33	10.79
4	31.3	3	N.A.	15.25	--
5	452.3	50	13772.8	22.14	--
6	500.0	201	20050.0	145.83	5.00
7	144.8	14	5872.9	37.25	11.00
8	188.5	33	7437.1	47.37	2.11
9	75.0	8	1473.4	16.25	7.50
10	88.2	10	1953.3	15.33	43.33
11	175.0	19	3634.6	7.65	--
12	759.6	76	21799.8	87.33	10.67
13	177.1	17	7704.3	58.22	2.86
14	162.0	18	4143.7	25.75	3.75
15	100.0	9	3037.6	53.24	2.75
16	194.8	44	7310.0	11.50	--
17	217.0	22	8000.0	22.00	--
18	200.0	20	N.A.	29.00	10.00
19	19.6	4	434.4	9.29	--
20	199.1	24	6957.0	62.50	2.50
TOTAL (20 sawmills)	4378.0	655	131981.6	758.54	117.33

(b) Long-distance shipments: depending on the weight, value and physical characteristics of the commodity, and the location of the customer, the shipment may be transferred to long-distance truck, rail, water or air.

(2) By-product and waste movement: this category includes shipments of those commodities which may or may not be sold, but whose production is essentially ancillary to the production of the main commodity. Examples from the lumber industry, in order of decreasing value per ton, are chips, sawdust, hog fuel. The same distinction between local and long-distance shipments applies, as above.

This trip classification ignores trips attracted to the site - to deliver mill and office supplies (including fuel), to repair or service machinery, and to deliver raw materials. In a complete study of the urban region, some of these trips would be classified as generated by other activities and need not be double counted. The main reason that trips attracted to the site were not included here is that they are a very insignificant part of total truck-trip making in and out of sites in the activities studied. Furthermore, data on their frequency are not readily available. The only cases in which trips attracted to approach a significant volume are for plywood mills.

By-product and waste movements did not enter the analytical stage of this study. The movement and disposal of waste material (household, commercial, and industrial) should be a distinct part of urban goods movement research and interface more closely with recycling research than does the approach taken here. A cursory examination of the use of trucks in this type of goods movement revealed extremely wide ranges of trip generation from zero to several hundred per month, mostly for very short distances. The transportation of hog fuel (a substance whose main ingredient is bark) exemplifies this instability. The supply of hog fuel is generally greatly in excess of demand and since it is an unavoidable product with low value and high bulk, many mills use it as boiler fuel to produce steam for mill processes. For such mills hog fuel may have to be imported from adjacent producers in periods of excess power demand. For mills which have switched to oil-fired furnaces, either for reasons of economy or municipal regulation, large quantities of hog fuel have to be shipped either to other mills for use as fuel, or to contractors and farmers as land fill. These activities are highly variable in their demands, and very sensitive to price changes.

The demand for chips and sawdust exhibits similar though lesser variations; they find their main use as a raw material for the pulp and paper industry. Since the demand for chips and sawdust is normally concentrated in space, the larger sawmills tend to use barge transportation to pulp mills. Smaller mills in the urban area normally truck these by-products to the local stockpile of a major pulp company, from whence it is barged to the pulp mill. This difference in the scale of operations between large and small mills could account for differences in trip generation rates were this group of commodities to be considered.

This overview of the data requirements and survey procedure has necessarily emphasized the peculiarities of the manufacturing and distribution activity system under consideration. This is in line with earlier claims that the characteristics of truck transport and distribution are partly a function of the way in which commodities are spatially processed.

CHAPTER VI

A TEST OF THE INDUSTRIAL PLANT-SIZE MODEL

It was seen earlier that the usual method of estimating trip generation rates from non-residential sites relied on either floor space or employment as the independent variable. Floor space was found to be a poor indicator of the propensity to generate truck traffic in earlier studies and its use has not been pursued here. An attempt was made to gather floor space data, but the problems of definition posed insurmountable difficulties, especially in an industry characterized by so much storage and production space which may be inside buildings, partially covered, or exterior. Also, questions relating to floor space usually met with no response due to ignorance. These conclusions do not necessarily mean that floor space should not be used in studies of non-industrial activities such as retail and office land uses.

This Chapter not only tests the effect of total employment size on the propensity to generate trips, it also adjusts employment by the quantity of production which is marketed locally, and measures the level of association between employment, production and shipments for the industry as a whole using aggregate published data.

The Plant-Size Model: A Test Using the Vancouver Survey Data

The most common form of model of commercial vehicle trip generation postulates that there exists:

(a) A close relationship between total employment and total truck trips generated at manufacturing sites.

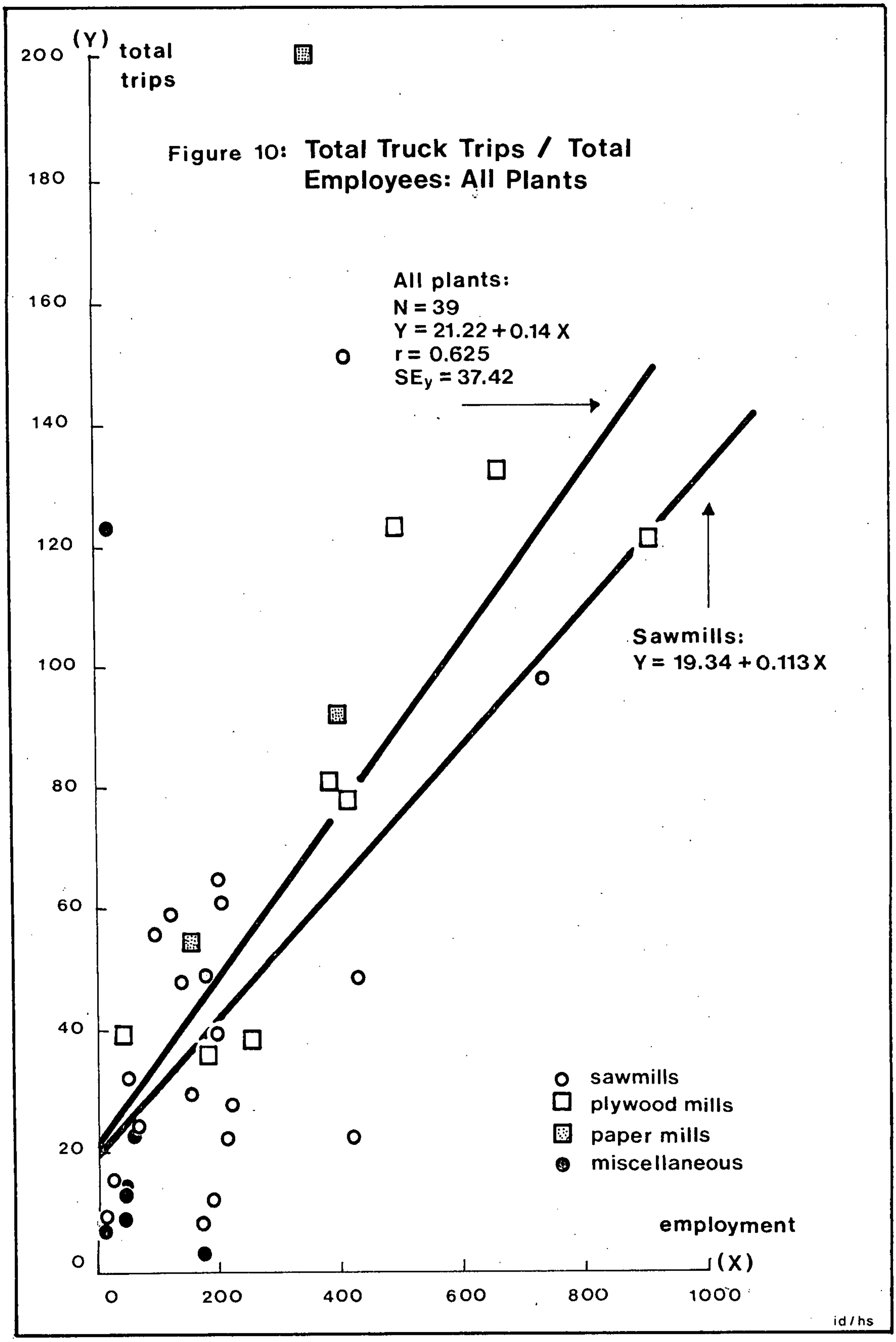
(b) Higher correlation coefficients between employment and trips for individual industries than for all firms combined.

These claims were tested using the following variables:

(a) Total trips: this includes all truck trips from the site except by-product and waste movement. Excluding these latter trips should improve the relationship between trips and employment for reasons explained in Chapter V. "Total trips" here refers to trips per week; it is calculated by summing all trips to local destinations, including those to dock-side, truck terminals, etc., and those direct to non-local destinations. The monthly total surveyed is adjusted by 5/D, where D = the number of working days in the month in which the survey was conducted, to obtain trips per week.

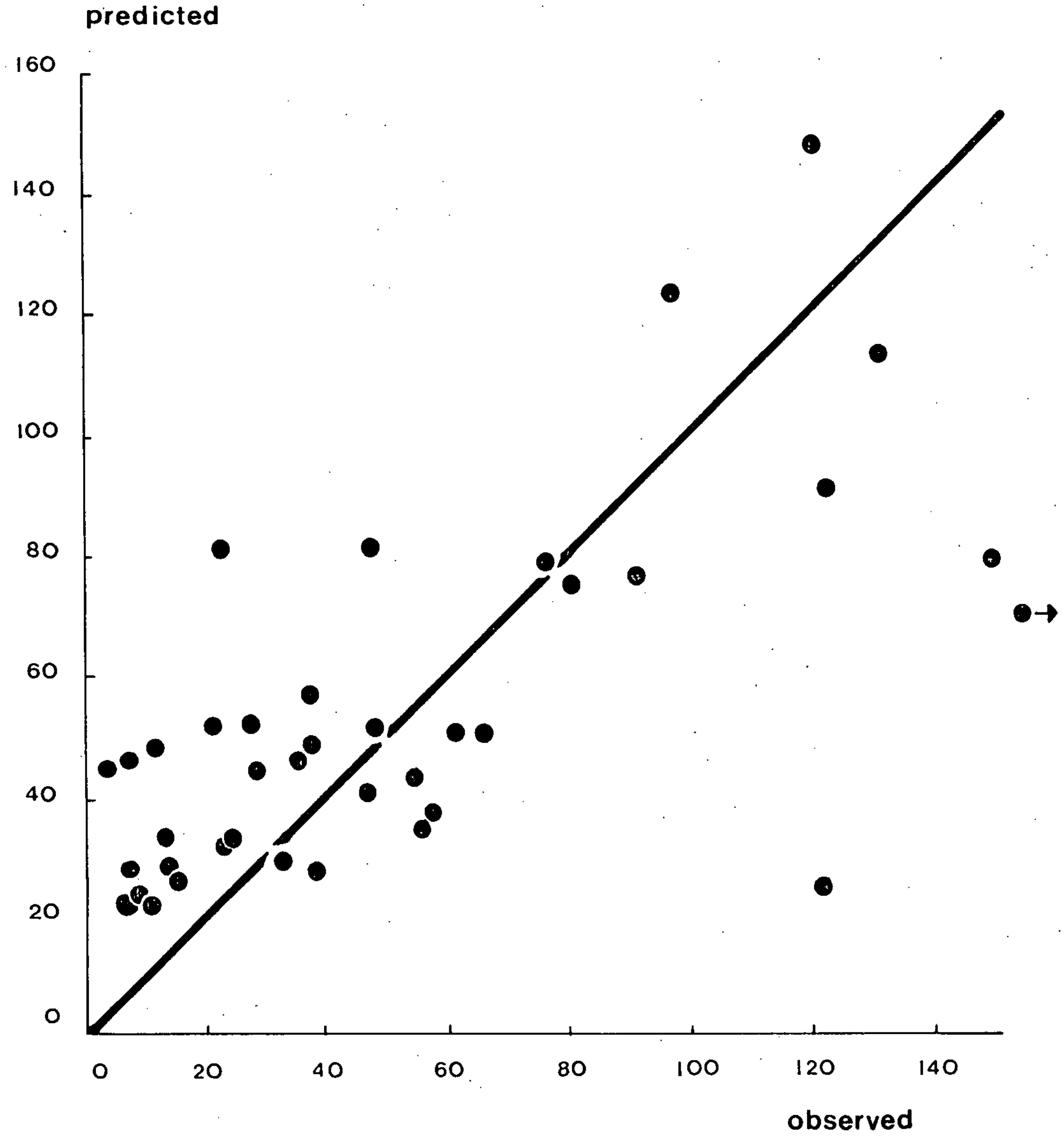
(b) Employment: average production and maintenance workers in the month of the survey.

Figure 10 shows an adequate overall fit of the data to the plant-size model, but the significance of the relationship is influenced by the few high values of X (employment).



200
180
160
140
120
100
80
60
40
20
0
(Y) total trips
Figure 10: Total Truck Trips / Total Employees: All Plants
All plants:
N = 39
Y = 21.22 + 0.14 X
r = 0.625
SEy = 37.42
Sawmills:
Y = 19.34 + 0.113 X
sawmills
plywood mills
paper mills
miscellaneous
employment
(X)
0
200
400
600
800
1000
id / hs

Figure II: Residuals From Regression (Figure 10): All Plants



id/hs

Also there is a very poor fit for any one size group of plants.

Extracting a homogeneous group of plants (sawmills) from the total does not improve the results. (Fig. 12). This either disproves the hypothesis that there is a closer association between employment and trips for separate industries than for all firms combined, or suggests that sawmills, plywood mills, and other mills included here are properly classified as one industrial activity system. The pattern of residuals for sawmills is similar to that for all firms, and the correlation coefficient is lowered to the point where its significance is doubtful at the 99% level. There is, however, evidence of non-linearity in the data because of the high constants (All plants: 21.22, Sawmills: 19.34) and the overpredictions of the majority of small plants in both equations. A test using $\log_{10}X$ failed to improve the relationship, mainly because of the very wide scatter and low number of observations for higher values of X.

The reasons for the poor estimates of trip generation rates using total employment can be divided into two groups: different market characteristics of the plants, and different productivity rates (quantity in weight or volume per employee). The question of productivity per employee will be considered first. There are two basic effects on regression relationships which may be expected from different productivity rates between firms. <u>High quantities manufactured</u> per employee within an industry should cause the regression lines in Figures 10 and 12 to shift to the left as more

Figure 12:

Total Trips/Total Employment For Sawmills

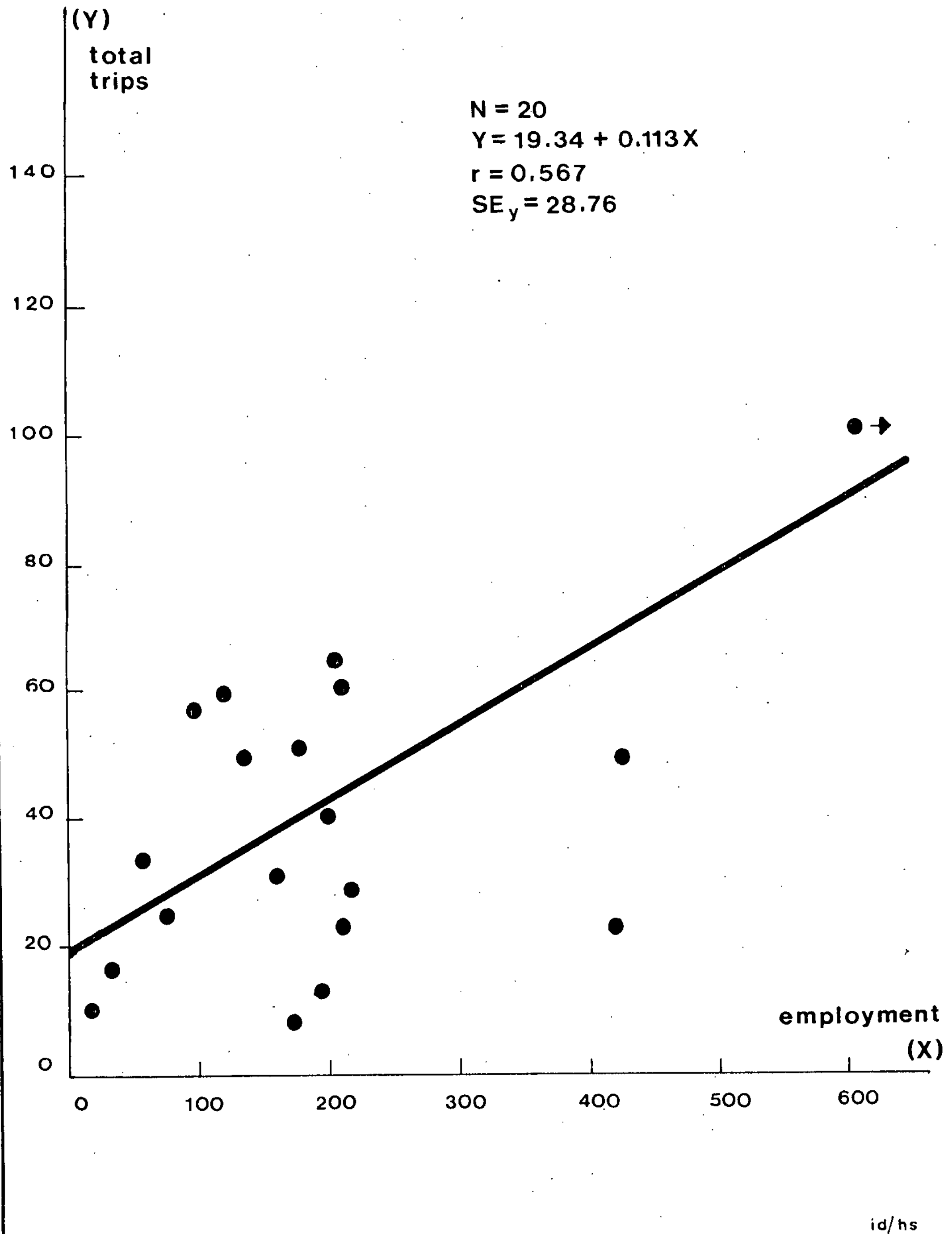
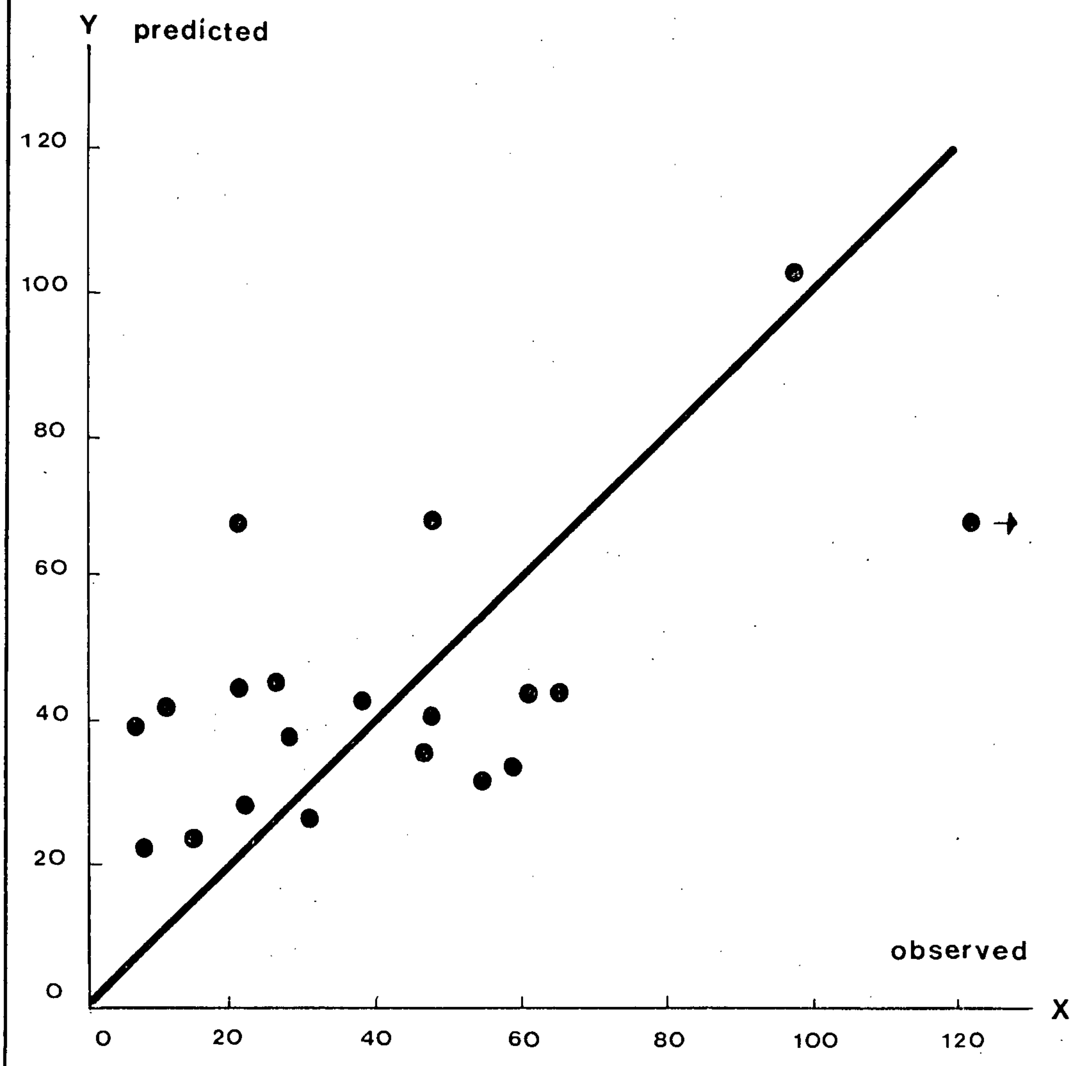


Figure 13:

Residuals From Regression (Figure 12): Sawmills



trips per employee are required to move the commodity. For this reason we might have expected the sawmill regression line for "All Plants" to move to the left. Economies of scale in production, especially those of higher productivity with increasing plant size, should cause increasing trips per employee as plant size (employment) increases. If this were associated with higher load factors on trucks, there should be a declining rate of increase in trip generation rates per employee as firm size increases. In fact this does not appear to take place. Industries exhibiting strong scale economies (such as paper and plywood mills, Figure 10) have relatively high trip generation rates which seem to increase linearly with firm size. This suggests that there is little room for improving load factors as production increases.

The effects of productivity levels are difficult to detect using total employment because of the importance of the characteristics of the market for the product. The influence of the spatial extent of the market and local distribution channels deserve primary consideration.

Trip Generation Rates and Market Distance

The most significant transport aspect of a plant's market is the physical distance between production and point of re-sale or consumption. Here the question of modal split, particularly between truck and rail transportation, enters a complete model. For two reasons, it is ignored in this analysis. First, "local" is defined as comprising the Lower

Fraser Valley (Vancouver and all points to 90 miles east). There is almost no rail traffic which originates in Greater Vancouver and terminates elsewhere in this region (at least in the case of the commodities considered here). There is also very little truck traffic originating in the urban area (Greater Vancouver) and terminating outside the region. Exceptions to this are:

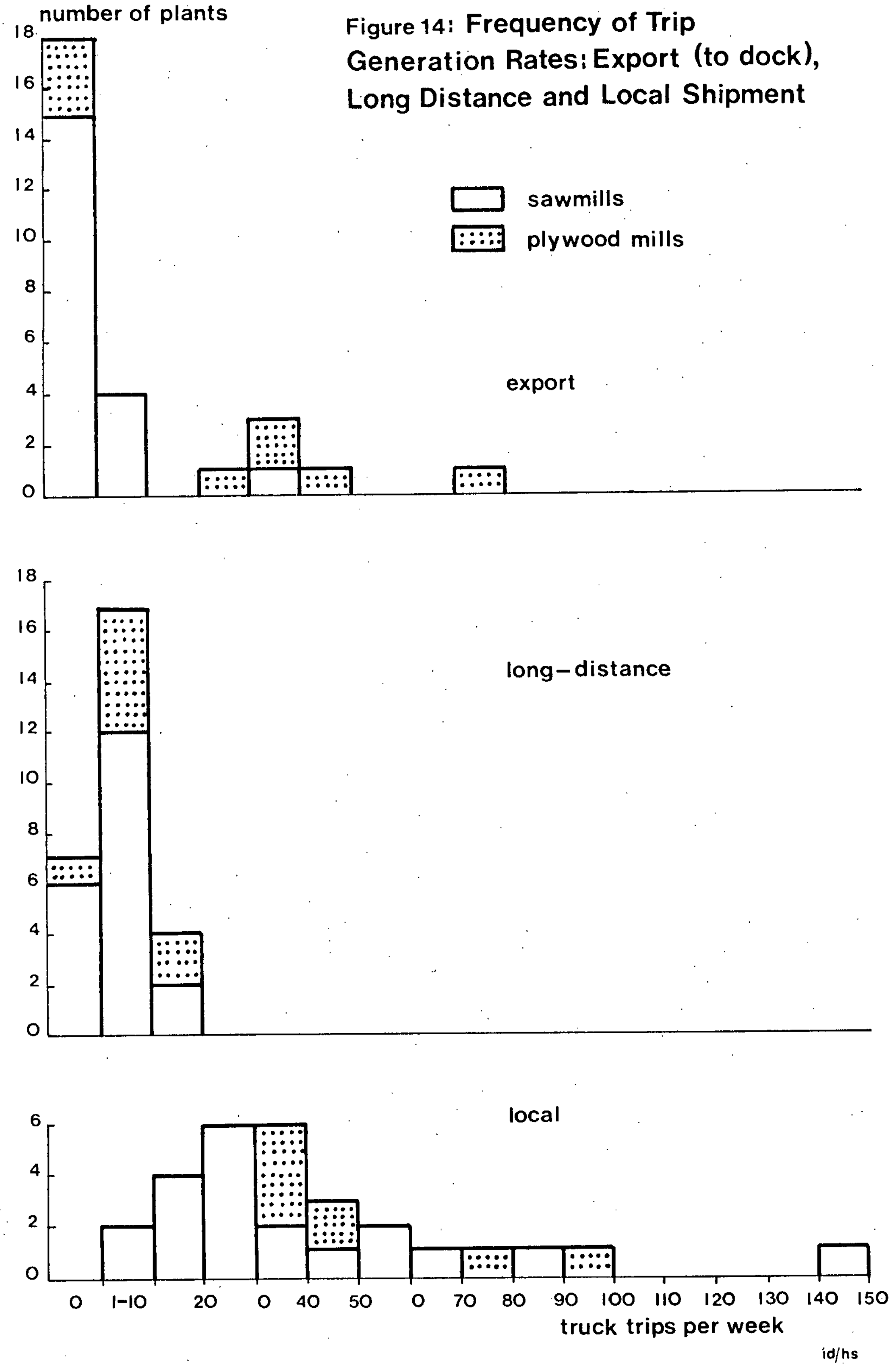
(a) Direct shipments to Vancouver Island, the U.S. (Washington and Oregon), and scattered points in the rest of B.C. and the prairie provinces.

(b) Mode-transfer shipments to these destinations, especially paper products to Canadian destinations, which for small shipment sizes are transferred to inter-city truck, and wood products to coastal points which are shipped via water as general freight.

(c) Overseas or coastal shipments transferred to the dock by truck.

The significance of these shipments for sawmills and plywood mills is shown in Figure 14, which illustrates the number of plants falling into each trip generation rate size category with trips distinguished by purpose. Truck-to-dock exports and long-distance (i.e., outside the Lower Fraser Valley) are insignificant for the majority of mills. Plywood mills throughout tend to have higher trip generation rates than sawmills, mainly because of the larger average size of plants. However the difference is accentuated in

Figure 14: **Frequency of Trip Generation Rates: Export (to dock), Long Distance and Local Shipment**



the case of export shipments. This is probably due to several factors:

(1) Plywood is more perishable product than lumber. Because of the general lack of covered storage space at the dockside, inventories for overseas shipment tends to be forced onto the manufacturer. Since production is continuous, but the arrival and departure times of ships is highly discrete and controlled by a variety of factors beyond the influence of the manufacturer, the shipper cannot risk outdoor storage at the dockside by total reliance on barge transportation.

(2) Related to (1) is the fact that the crucial question when the ship is in port is turnaround time; trucks are the fastest and more reliable mode for ensuring that the product is moved from inventory to ship's hold effectively.

(3) It is also possible that the export market for plywood is more significant than that for lumber. Observations of the frequency of lumber-carrying barge traffic from sawmills indicates that this possibility is insufficient to nullify the other factors.

Some other observations may be made on the relative magnitudes of trips for different purposes (Figure 14). One sawmill has an unusually high trip generation in the export category. This plant was without a barge-loading ramp at the time of the survey and has since closed down. It would be premature to suggest that the lack of barge access was a factor in the closure, but this is an interesting possibility in the light of the above considerations regarding truck/barge modal split.

Shipments to dock are highly unstable through time, especially for plywood. Sudden bursts of truck activity take place between the plant and the dock whenever a ship is in port. This is another indication of the dependence of plywood upon covered storage and its ability to travel by non-bulk modes, at least for short distances. However, this irregularity of shipments means that data gathered on a monthly total basis and reduced to per week averages is quite unreliable. It points out the need for research into the interfacing of different modes of transport in urban areas. The need to reduce urban truck movements and yet retain low ship turnaround times is a main reason why the Seaboard Terminal on the north shore of Burnard Inlet is being given substantial indoor storage facilities and shipside barge-unloading access. Further innovations in the terminal (urban) distribution process similar to Seaboard's development, as well as large ship sizes, will contribute to a stabilization, if not reduction of this type of traffic in Vancouver.

Because of the irregularity of shipment to the dock, and the apparent dependence of truck usage for this purpose on factors beyond the consideration of this study, these trips generated by plants were dropped from total trips.

Other long-distance shipments were omitted as well because of their insignificance, leaving a residual of purely local trips.

The omission from the plant size model of formal recognition that much of a plant's output may be shipped by non-highway modes of transport can be rectified using the basic/non-basic dichotomy. Based on the assumption that the percentage of employees producing for the local market is equal to the percentage of quantity produced that is shipped to the local market, non-basic (local) employment is equal to:

$$X_l = X_t \cdot \frac{Q_l}{Q_t}$$

where:

X_l = non-basic employment

X_t = total employment

Q_l = Local quantity of product shipped per month

Q_t = Total quantity shipped per month

This assumption presumes that:

(a) The product sold on the local market requires an equal quantity of labour in the production process to the one sold on the export market.

(b) The lag between production and shipments is equal for local and long-distance markets.

There are several circumstances in which these assumptions may not be met. It could be hypothesized that the closer the product is to its point of final consumption, both in space and within the channel of distribution, the more "processed" it is likely to be. "Processed" includes not only the physical state of the product, but also it sorted and packaged state. Export shipments may be less processed than local shipments, implying that the latter requires a greater labour input. Assumption (a), that of a homogeneous production function with respect to labour within each plant, does appear to be reasonable within the wood products activity system.

Assumption (b) is more serious. A simple causal chain of employment - transportation demand ignores the possibility of lags between employment/production and production/shipments. There are probably insignificant lags between employment and production; the two should vary together in labour-intensive industries. Where the inventory function falls to the manufacturer in the channel, there are likely to be significant lags between production and shipments. The causes and significance of lags will be considered in the chapter on forecasting (Chapter IX). At the moment our concern is to improve the plant-size model using easily accessible information, so the problem of transportation demand lagging employment will be assumed to be negligible.

The estimation of non-basic employment requires the ratio between the quantity shipped to local destination and the quantity shipped out of the urban region. Quantity measures were consistent within each plant; the units normally used were:

Sawmills: Board feet. A board foot is equivalent to a 12" x 12" x 1" piece of lumber.

Plywood and panelboard mills: 1/16ths and 3/8ths. This is equivalent to panels of 12" x 12" x 1/16" or 3/8" dimensions.

Paper mills: Weight (lbs.)

Quantity shipped locally may be calculated by summing the quantities carried on local truck trips. Plants frequently have records of "total local shipments" by month. If these are used instead of the summed local trips two sources of error are introduced: the definition of local may be different to the one used here, and accounting practice may record sales rather than shipments. The same problems apply to defining total shipments. Wherever possible (in about 75% of the cases), total shipments were estimated from records of water, rail, long distance and local truck shipments. The percentage error compared with the total quantity recorded by the plant was almost always minimal, and the latter quantity has been used here.

The revised estimate of trips generated by the plants showed no improvement in the correlation coefficient for the grouped data (0.676 compared with the previous 0.625). For sawmills alone, however, the correlation coefficient moved from 0.567 to 0.843 (Figure 15). This indicates that sawmills can indeed be considered a distinct activity in terms of their trip generation rates. The constant is reduced

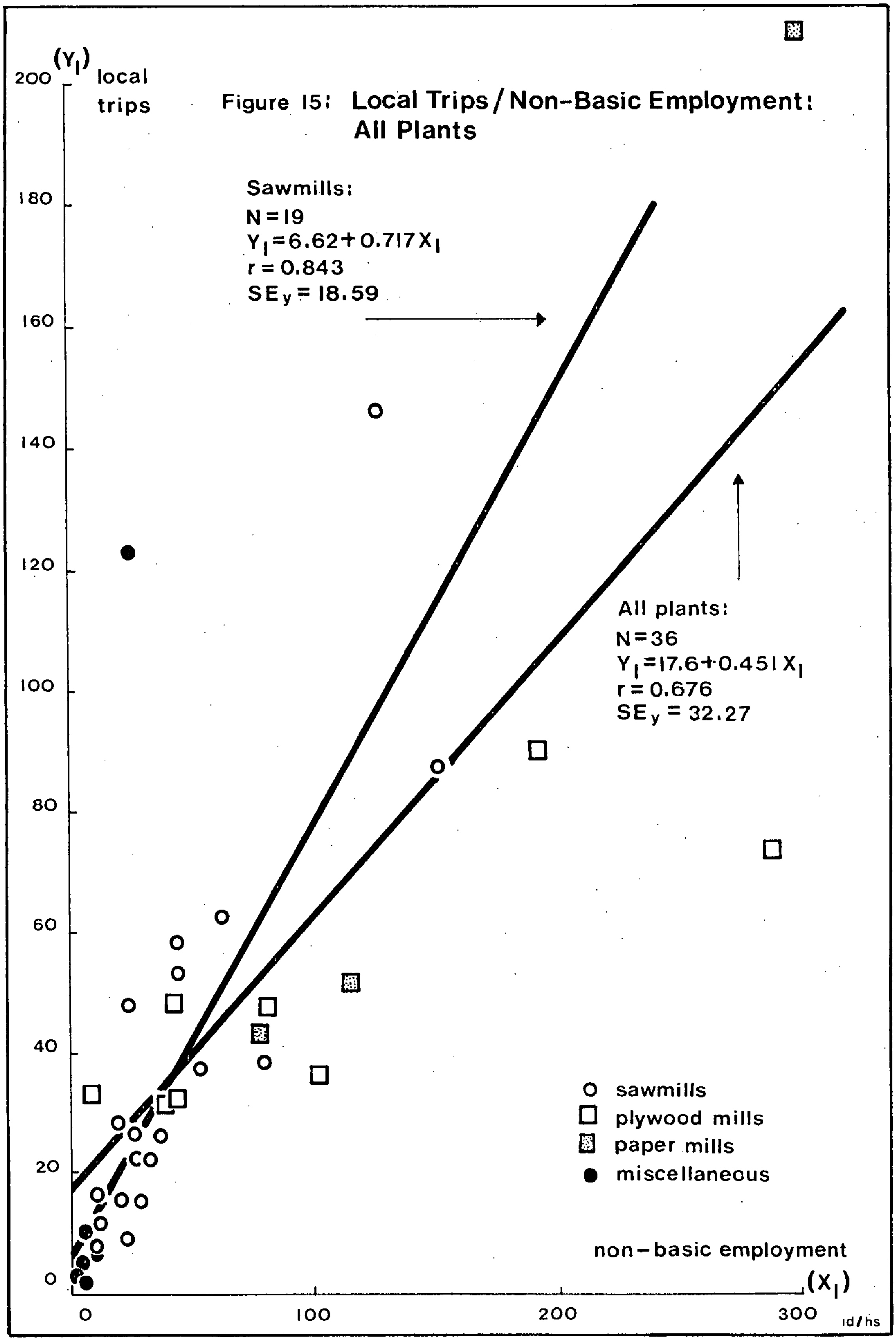
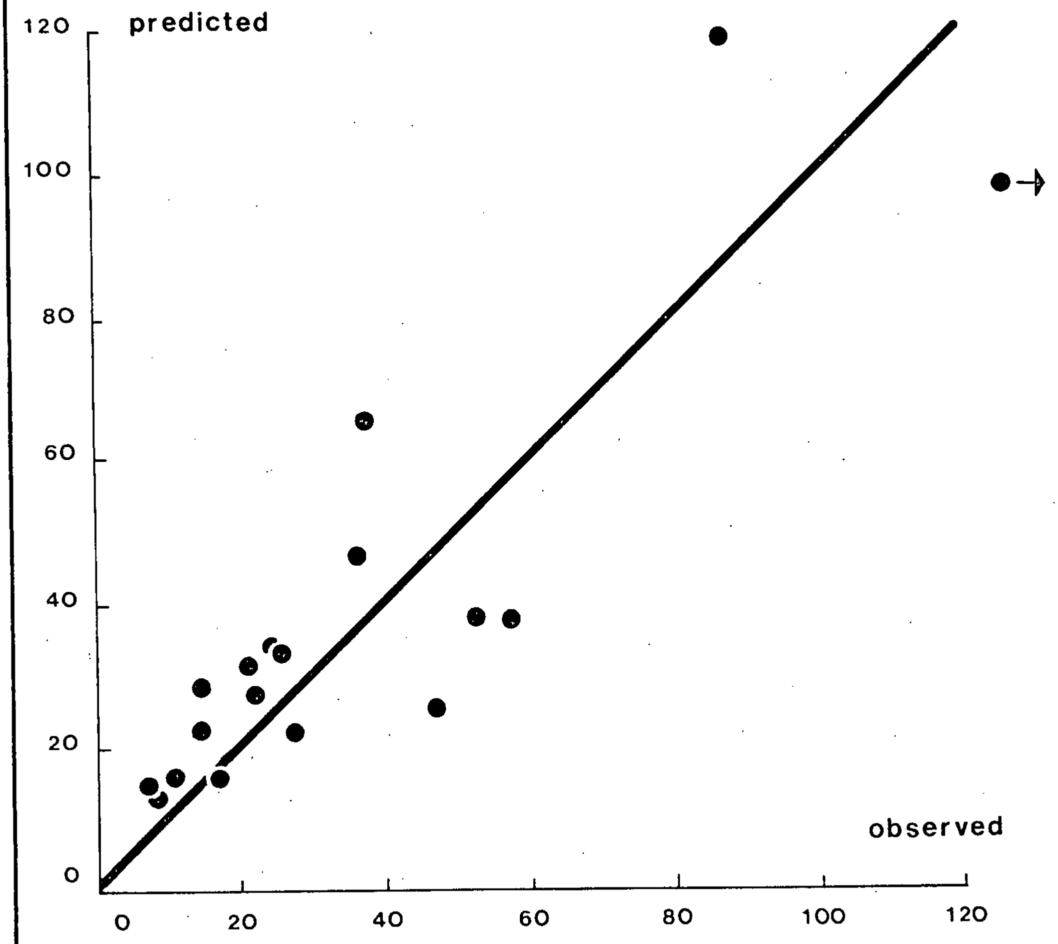


Figure 15: Local Trips / Non-Basic Employment: All Plants
(Y_l) local trips
200
180
160
140
120
100
80
60
40
20
0
Sawmills:
N=19
$Y_l = 6.62 + 0.717 X_l$
r = 0.843
SE_y = 18.59
All plants:
N=36
$Y_l = 17.6 + 0.451 X_l$
r = 0.676
SE_y = 32.27
sawmills
plywood mills
paper mills
miscellaneous
non-basic employment
(X_l)
0
100
200
300
id/hs

Figure 16:

Residuals From Regression (Figure 15): Sawmills

$Y_l = 6.62 + 0.717 X_l$
where
Y_l = local trips
X_l = non-basic employment



id/ hs

to a manageable size: just over one trip per day. Unfortunately a plot of residuals shows a heteroscedastic tendency and a continuing poor fit for larger firms (Figure 16). Again, tests using $\log_{10}X$ lowered the correlation coefficients both for sawmills and all plants combined.

It would be useful to by-pass the need for data on the percentage of total quantity that is shipped to local markets by establishing a relationship between total employment and percentage of market which is local. In other words, if we are aware of a functional relationship between Q_l/Q_t and X_t (total employment), the number of data items required for each firm to estimate X_l (non-basic employment) is reduced from three to one.

There are probably wide differences between the form of $Q_l/Q_t = f(X_t)$ from industry to industry. However, it is probably true to say that the more homogeneous the characteristics of products between firms within any one industry, the more likely there is to be a significant inverse relationship between percent of market which is local and plant size. This is because in the relative absence of specialization in product characteristics, specialization will occur in the spatial characteristics of the market. As heterogeneity of the products within an industry increases, the inverse relationship between Q_l/Q_t and X_t is not as much likely to become positive as become insignificant. Thus the useful existence of such a function will depend on the definition of "an industry".

Supposing the sawmill industry to have fairly homogeneous product characteristics, we may hypothesize the type of functional relationship: $Q_l/Q_t = f(X_t)$. Larger firms are probably in existence as a result of the control they have established over long-distance markets. Increasing plant size may therefore be associated with a decreasing percentage of production destined for local markets. This is supported from another perspective: there are probably few economies of scale in lumber production (unlike the situation in log-supply and lumber marketing) and local prices for lumber between large and small manufacturers are consequently not significantly different. Thus the share of the local market is not expected to vary with size of firm, and even the largest firms may be expected to retain a foothold in the local market given the simple physical distribution structure of lumber marketing at the local scale.

The smaller the firm, the more of its production might be expected to be allocated to local markets. Part of the reason for this is that the smallest firms probably do specialize in custom-cut lumber for a very small number of customers and therefore locate close to these customers. They are likely to have less productive flexibility for meeting orders unusual in their size or specification characteristics from customers at a distance, and are unlikely to seek such orders because of the high risks involved. We might also hypothesize that the firm would not have to be very large before it escaped from this position of "imprisonment" in the local market. The existence of international lumber marketing associations makes access to non-local markets almost equally possible for small-medium and large firms.

It may be concluded from the preceding argument that the correlation of Q_l/Q_t on X_t would be described by a rapidly downward sloping curve with small firms having much of their shipments to local markets but small-medium firms soon entering the non-local market area.

The slope would decrease as medium to large firms retain a foothold in local markets, and decrease at a decreasing rate as large firms are able to take advantage of their reputation even at the local level. Therefore a hyperbola of this form was fitted to the data:

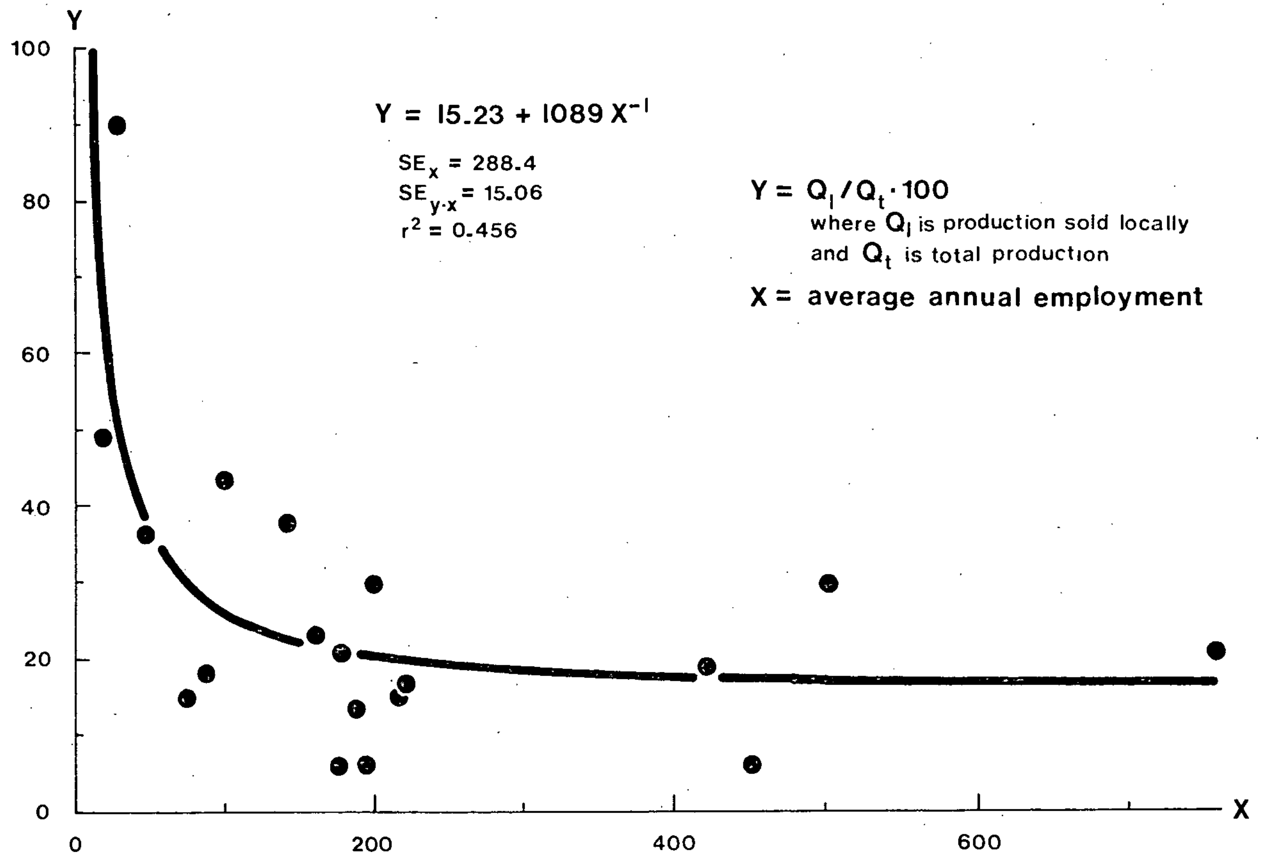
$$Y = a + \frac{b}{X_t}$$

where: $Y = 100\ (Q_l/Q_t)$ = percent of production shipped to local markets

$X_t =$ total employment

The result (Figure 17) was a surprisingly good fit, and sufficient to conclude that further research on such functions might significantly reduce data requirements in this area. If we know the relationship between plant size and quantity of product marketed locally, clearly we do not need a survey to find "non-basic" or locally-oriented employment. In turn, this means that local trips can be estimated from total employment with greater accuracy.

Figure 17: Plant Size vs. Range of Sales



id/hs

Employment-Local Shipment Correlation: A Comparison With Aggregate Data

The remainder of this chapter seeks to compare aggregate (industry-wide) data with disaggreate (individual plant) data with a view to further examining the relationships between employment, production, total and local shipments.

Data were obtained for the majority of plants on monthly production, total shipments, local shipments, and employment for the year 1970. The correlation coefficients for these variables are shown in Table 4. A blank in any cell in Table 4 indicates either a lack of data or a variable remaining constant. The latter is frequently the case with employment for the smaller plants, since these mills tend not to add or delete whole shifts through the year. The highest coefficients should exist between pairs of variables adjacent in the chain of production. Thus high coefficients should exist between employment and production, production and total shipments, and total shipments and local shipments. For each pair of variables, we can suggest factors which contribute towards reducing the value of r. A_1/A_2: products vary in the amount of labour required in their processing; a change in product (lumber type) produced within the year can hold quantity produced constant and change the amount of labour required. A change in volume of production may cause a non-proportional change in employment because

TABLE 4

CORRELATION COEFFICIENTS: PRODUCTION, SHIPMENTS LOCAL SHIPMENTS, EMPLOYMENT

Where: all variates are totals per month
A_1 = Total employment
A_2 = Total production
A_3 = Total shipments
A_4 = Local shipments
* = Significant at 95% level

A_1/A_2	A_1/A_3	A_1/A_4	A_2/A_3	A_2/A_4	A_3/A_4	
-	-	-	-	-0.085	-	
0.449	0.823*	0.802*	0.607*	0.393	0.859	
0.397	0.617*	0.300	0.598*	0.303	0.651*	
-	-	-	-	-	-	
0.581*	0.749*	0.371	0.711*	0.474	0.409	
0.391	0.148	-0.234	-0.348	0.393	0.511	
0.671*	0.662*	0.370	0.314	0.231	0.695*	
0.036	-0.130	0.367	0.584*	-0.328	-0.169	
-	-	-	0.236	-	-	
0.867*	0.403	0.511	0.399	0.601*	0.412	Saw-
-	-	-	0.374	-0.207	0.116	mills
-0.125	0.009	-	0.579*	-	-	(survey)
-0.237	-0.109	-	0.422	-	-	
-	-	-	0.882*	0.811*	0.880	
-0.325	0.224	-0.210	-0.002	-0.407	-0.308	
-	-	-	-	-	-	
-	-	-	-	-	-	
0.320	-0.223	-	0.319	-	-	
-0.139	0.153	0.264	0.436	0.159	0.525	
0.614*	0.539	-	0.403	-	-	
-	-	-	0.450	-0.135	0.614*	Ply-
0.648*	0.731*	0.505	0.812*	0.502	0.589*	wood &
-	-	-	-	-	-	Panel
0.838*	-	-	-	-	-	Mills
-	0.477	-	0.667*	-	-	(survey)
0.316	0.481	-	0.903*	-	-	
0.679*	0.404	-	0.659*	-	-	
0.791*	0.249	0.038	0.503	0.264	0.774*	Coast Sawmills 1970(D.B.S.)
0.420*	0.224	0.279*	0.551*	0.479*	0.468*	Coast Sawmills 1966-70(DBS)

some processes performed within the plant are less labour-intensive than others or because of different levels of machine capacity-utilization.

A_2/A_3: production and shipments often do not vary together because of differences in the timing of supply of materials and the demand for the product. This difference is at a minimum where the producer is able to abdicate the inventory function within the channel, which is not the case in the sawmill industry.

A_3/A_4: local shipments and total shipments are related to the extent that a plant's local market behaves in a way similar to its total market, including export shipments.

The three relationships above can be hypothesized to be closer than others. Employment (A_1) and local shipments (A_2) are especially difficult to associate, given the intervening influence of production and total shipments.

For comparison purposes, the equivalent Statistics Canada data are shown in Table 5. The pairs of variables are ranked below according to the frequency of their being significant in the case of the sawmill survey) and their absolute value in the case of Statistics Canada data.

The 1966-1970 data generate unreliable coefficients because of the trend component in the data. In addition to the factors which tend to lower r values for the survey (individual plant) data there must be added the effect of different productivity per employee rates between plants,

Table 5

Rank of Correlation Coefficients: Sawmills

Pairs of Variables	Sawmills (survey)	Coast Sawmills 1970*	Coast Sawmills 1966-1970*
Total employment/ total production	3	1	4
Total employment/ total shipments	2	4	6
Total employment/ local shipments	6	6	5
Total production/ total shipments	1	3	1
Total production/ local shipments	5	5	2
Total shipments/ local shipments	4	2	3

*Source: D.B.S. Catalogue No. 35-003: Production, Shipments, and Stocks on Hand of Sawmills in British Columbia.

and different market and transporation modes. It seems, however, that total employment and total local shipments are the least-related variables. As was seen in Figure 14, local shipments account for the bulk of truck traffic from sawmills and plywood mills. An insignificant relationship between total employment and truck trips is therefore an industry-wide characteristic.

This chapter has discussed how appropriate data were collected and has suggested improvements to the process, including the possibility that the identification of functional relationships between total employment at a site and the percentage of total shipments destined for local markets might in future lead to a reduction in data requirements. This in turn will depend upon how effectively "local market" can be defined; in the Vancouver case we are perhaps fortunate in that the local market is well demarcated by sea, mountain, and political barriers.

It was noted that a variety of products may be shipped from one site, even in an industry as ostensibly simple as the sawmill industry. A perfectly adequate trip generation study would need to quantify the magnitude and variability of these other movements, especially those related to waste disposal.

Difficulties associated with measuring trip generation rates for periods of less than a week were anticipated. Here also, future research should be able to establish an optimum time unit to be used for each industry based on the variability of shipment volumes and data collection costs.

The definition of "an industry" is important to the reliability of estimates. It appears that firms should be grouped according to product characteristics, that is to say their physical attributes (for transport purposes) and their substitutability in use (to standardize for the market's competitive structure).

Above all, there is only a weak relationship between local truck trips and total plant employment. Intervening variables - lags between production and shipments and the proportion of shipments marketed locally - are significant in reducing the capability of within-site unadjusted data, such as total employment, to estimate local trips.

CHAPTER VII

A TEST OF THE MARKETING MODEL

This chapter estimates the effects that the types of local destination have on truck trip generation rates. Marketing factors, such as the proportion of production shipped directly to retailers or manufacturers, are combined with the basic plant-size model discussed previously. An improvement in the ability to estimate trip generation rates is observed. The size distribution of shipments, so critical for trip generation rates, is analyzed in some detail. The transportation demands peculiar to the "miscellaneous" category of plants are described on a disaggregated basis in order to observe how special market characteristics lead to distinctly different types of transport demand.

The survey of Vancouver wood products plants assembled a data bank on the destinations of truck trips. These destinations were classified into activities as shown in Tables 6 and 7. The percentage of product and the percentage of trips to each activity type is presented in Tables 6 and 7 respectively. These data form the raw material for the analysis of distribution channel/trip generation rate relationships.

TABLE 6: Percentage of Total Local Trips to Each Customer Type

Customer	SAW	PLY	MILL	FAB	BOX	FURN	HAND	PRSV	MISC	R1	R2	R3	R4	RX	Const.
Sawmill Number 1	8.333		10.417	2.083	6.250					8.333	13.542	7.292	13.542	29.167	1.042
2	38.318	1.869	3.738		2.804					31.776	11.215	5.608	0.935	3.738	
3	31.210	1.274	20.390							21.656	12.739	4.459	1.274	3.822	3.185
4	15.517		34.483					27.586	5.172		8.621	8.621			
5	18.033		1.639							16.393	14.754	4.918	27.869	16.393	
6	3.086	0.617	3.086	1.235	1.235	0.617		5.556	1.852	28.395	27.037	1.852	4.321	9.259	1.852
7	72.535		8.451							7.747	5.634	4.930		0.704	
8	1.705		1.136					0.568	0.568	22.727	26.705	14.773	1.136	14.773	15.909
9	11.111		5.555		2.778				8.333	19.444	30.556	2.778		19.444	
10	44.444		11.111		8.889			4.444			31.111				
11			20.833									79.167			
12	52.632	1.215	8.907	0.405	0.810					8.097	11.741	2.834	0.810	12.551	
13	15.385	0.699	2.797		2.797		2.797		4.196	13.287	34.965	7.692	1.399	13.986	
14	14.433		4.124	3.093	1.031				2.062	22.680	21.650	19.588		7.217	4.124
15	20.657		0.939	4.225						31.455	31.455	3.286	1.878	3.286	2.817
16	17.391										4.348	8.696	8.696	47.826	13.044
17					4.762				9.524	33.333	33.333	4.762		9.524	4.762
18	65.517		13.793							6.897	10.345			3.448	
19	40.909		4.546						9.091	4.546	4.546	13.636			22.727
20	12.340	6.383	6.383	1.277	4.255			5.106	0.426	18.723	28.511	4.681	0.851	10.213	0.851
Plywood	2.312	10.983	20.809	0.578				0.578	12.139		1.734		49.711		1.156
and		37.735	3.774	9.434		1.887		3.774		11.321	28.302			1.887	1.887
other		10.588								7.059			81.177	1.177	
Panel	10.526	2.105	4.211		1.053	5.263		2.105		27.368	16.842		6.316	21.053	3.158
Mills	0.781			1.563		21.094				32.813	30.469		2.344	9.375	1.563
		62.698	9.329										27.973		
					3.252	0.813				52.845	25.203	2.439	9.756	5.691	
	0.909	7.273	2.727										89.091		

KEY TO CUSTOMER TYPES

- SAW — Sawmills
- PLY — Plywood and Panel Mills
- MILL — Sash, Door and Millwork Plants
- FAB — Pre-fabricated building plants
- BOX — Wooden box and pallet plants
- FURN — Furniture plants
- HAND — Wooden handle and turning industry
- PRSV — Wood preserving
- MISC — Other types, nec
- R1 — Retailers (50% sold to consumers)
- R2 — Retailers (50% sold to construction industry)
- R3 — Office wholesalers
- R4 — Other retailers mainly those who sell to manufacturers and retailers
- RX — Retailers which cannot be classified because of lack of data.
- Const. — Construction firms

Table 7: Percentage of Total Local Quantity to Each Customer Type

Customer	SAW	PLY	MILL	FAB	BOX	FURN	HAND	PRSV	MISC	R1	R2	R3	R4	RX	Const.
Sawmill Number 1	8.306		11.132	1.769	6.045					5.931	12.684	6.997	22.173	24.268	0.696
2	53.093	1.407	2.012		2.960					22.346	5.620	8.322	1.319	2.922	
3	38.188	1.418	26.025							12.725	7.803	5.062	1.653	4.971	2.155
4	13.762		41.081					32.533	5.502		2.484	4.638			
5	18.037		0.512							14.095	15.312	2.384	35.102	14.559	
6	1.523	0.001	2.811	0.865	1.064	0.048		4.847	1.275	28.628	39.168	1.374	5.241	10.446	2.710
7	74.973		9.170							6.453	3.839	4.326		1.240	
8	0.922		1.963					0.316	0.383	18.723	16.956	23.877	2.561	21.103	13.195
9	24.479		5.154						15.409	12.982	13.566	3.220		25.189	
10	47.208		9.037		4.551			5.017			34.187				
11			27.419									72.581			
12	63.667	1.172	10.914	0.077	0.226					4.055	7.901	3.340	0.465	8.184	
13	19.114	0.889	2.898		0.840		2.298		3.169	13.279	35.295	8.020	2.130	12.070	
14	19.560		11.198	5.739	0.392				0.692	12.008	17.167	29.027		3.345	0.871
15	32.337		1.477	3.587						22.087	30.633	5.154	0.996	1.648	2.080
16	19.637										5.488	13.093	10.823	44.007	6.952
17					6.761				7.530	49.178	23.766	0.710		8.534	3.522
18	67.052		23.805							3.856	3.704			1.585	
19	54.708		3.300						4.183	2.790	4.402	1.448			29.170
20	11.972	8.575	5.220	0.976	5.309			6.391	0.318	17.108	29.294	3.676	0.476	9.934	0.752
Plywood	1.787	5.897	20.697	0.079				0.014	8.519		2.429		59.789		0.790
and	N.A.														
other		18.314								8.450			73.161	0.075	
Panel	15.438	0.535	3.106		1.948	2.058		0.488		11.835	24.869		9.332	29.267	1.124
Mills	0.304			2.082		16.840				32.991	32.889		0.449	10.930	3.517
		46.942	0.699										42.359		
					2,516	0.477				45.067	29.842	0.513	12.826	8.763	
	0.105	5.882	4.533										89.480		

KEY TO CUSTOMER TYPES

SAW	Sawmill
PLY	Plywood and Panel Mill
MILL	Sash, Door and Millwork Plants
FAB	Pre-fabricated building plants
BOX	Wooden box and pallet plants
FURN	Furniture plants
HAND	Wooden handle and turning industry
PRSV	Wood preserving
MISC	Other types, nec
R1	Retailers (50% sold to consumers
R2	Retailers (50% sold to construction industry)
R3	Office wholesalers
R4	Other retailers mainly those who sell to manufacturers and retailers
RX	Retailers which cannot be classified because of lack of data.
Const.	Construction firm

Distribution Channel - Trip Generation Relationships: Regression Analysis

A cursory scan of distribution channels used by sawmills showed that two broad categories of immediate customer could be defined which accounted for over 90% of truck trips from each plant. These are trips to other manufacturers and trips to retail/wholesale activities. Within these groups are a wide range of sub-categories: these will be examined shortly. For the present, the percentage of a plant's monthly shipments moving to the retail/wholesale category is added to the plant-size regression equation on the premise that different types of institution in the channel are associated with different trip generation rates.

Allowance was made for the fact that productivity per employee may vary between plants. Another variable, output per employee, was defined as P/E where P is total annual production at the plant and E is mean annual employment. High productivity per employee should be associated with increases in trip generation rates per employee, other factors being equal.

The correlation matrix of these four variables is shown in Table 8. In a stepwise regression analysis, annual output per employee failed to make a significant (0.95 level) contribution to an explanation of the variance in Y_1. The resulting equation became:

Table 8

Correlation Matrix: Revised Model Variables

	Y_1	X_1	X_2	X_3
Y_1	1.0000			
X_1	0.8425	1.0000		
X_2	0.2219	-0.0880	1.0000	
X_3	-0.0099	-0.1019	0.3264	1.0000

Y_1 = local truck trips from sawmills

X_1 = non-basic employment

X_2 = % retail/wholesale in the local market

X_3 = annual lumber output per employee

$$Y_1 = -12.295 + 0.355X_1 + 0.721X_2$$

$$R^2 = 0.798$$

$$S.E.(Y) = 15.588$$

$$S.E.(a) = 9.095$$

$$S.E.(b_1) = 0.134$$

$$S.E.(b_2) = 0.094$$

where: Y_1 = local truck trips per week from sawmills.

X_1 = non-basic employment as defined in the plant-size model.

X_2 = percentage of local product shipped directly to retail/wholesale destinations.

A plot of the residuals (Figure 18) shows a distinct improvement in the estimation of trip generation rates for larger values of Y_1. The error variance has a more normal distribution, although the improvement in the percentage of variation in Y_1 explained ($r^2 = 0.710$ to $R^2 = 0.798$) is at the expense of accuracy for plants with low trip generation rates. Because of the influence of a few large values of Y_1, a negative value is estimated in the case of one plant.

The analysis was repeated, omitting the two largest values of Y_1 (145.8 and 87.33). The following results were obtained (Figure 19):

$$Y_1 = 9.509 + 0.599X_1$$

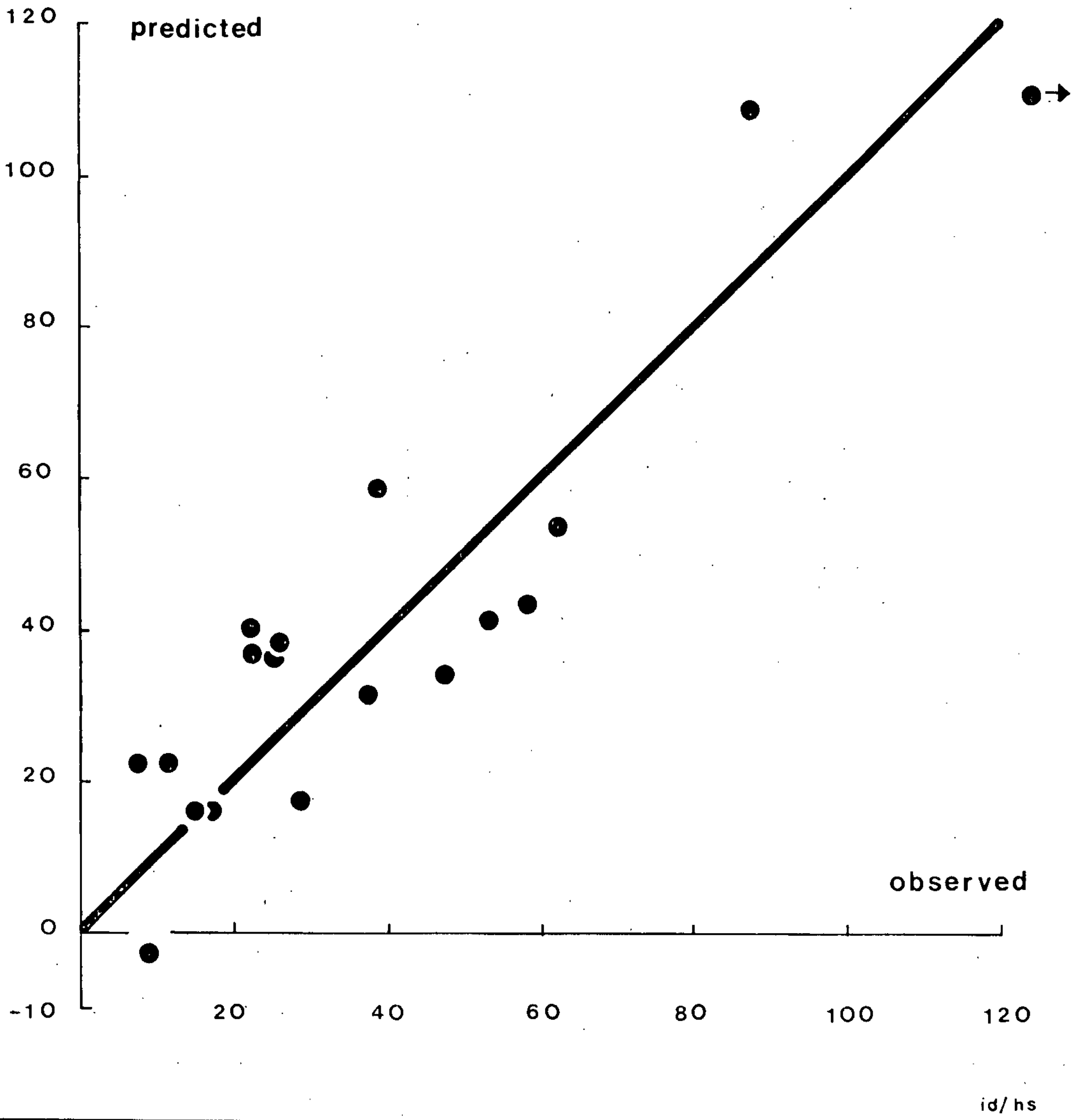
$$r^2 = 0.489$$

The percentage of total local quantity shipped to retail/wholesale (X_2) did not enter the regression at the 95%

Figure 18:
Residuals From Regression: Sawmills

$$Y_1 = -12.295 + 0.355X_1 + 0.721X_2$$

where:
Y_1 = local trips
X_1 = non-basic employment
X_2 = % retail-wholesale in local market



significance level. When forced into the equation, the result was:

$$Y_1 = -0.028 + 0.170X_1 + 0.62X_2$$

$$R_2 = 0.562$$

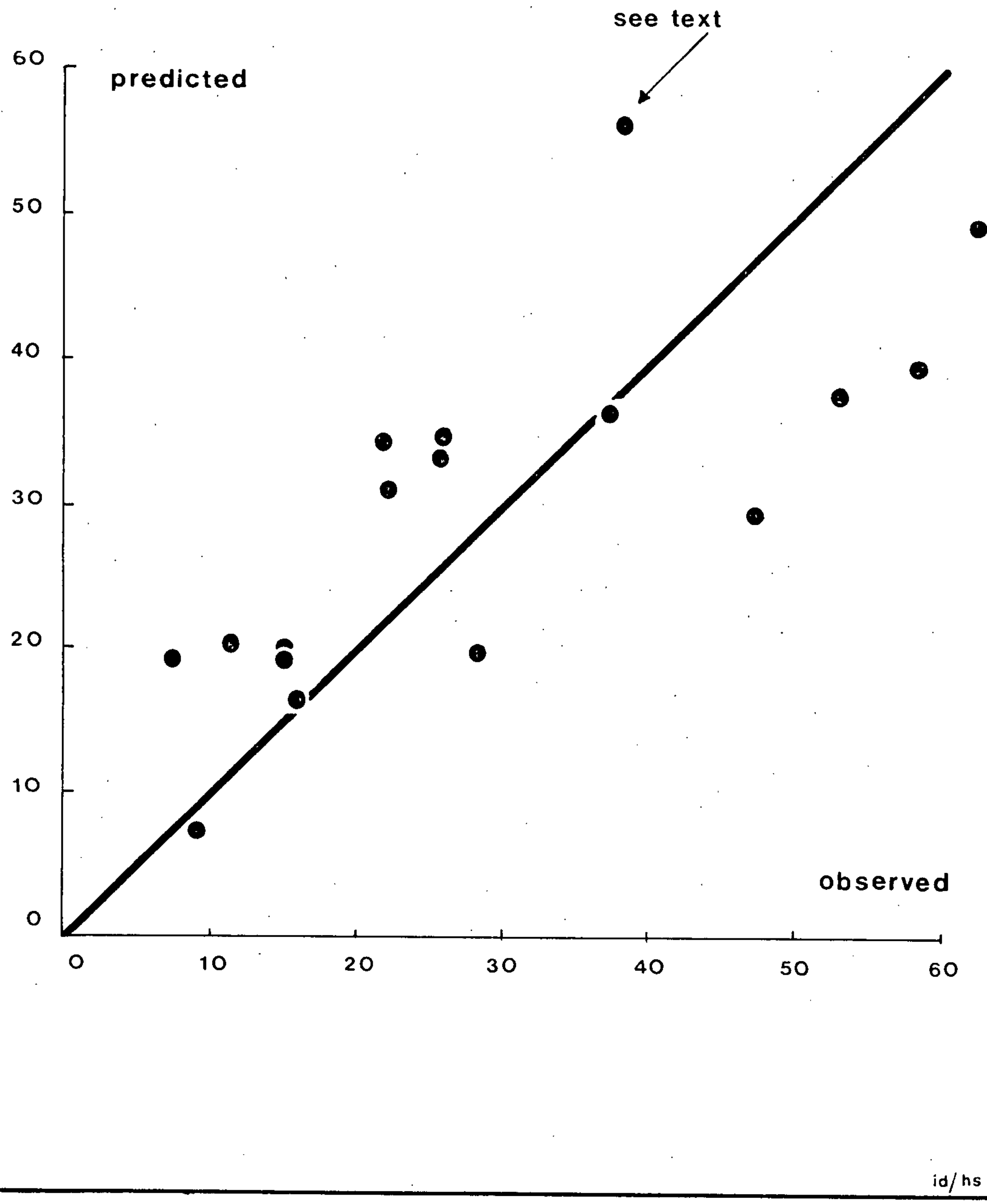
Again the improvement in estimations (using multiple rather simple linear regression) was most marked for higher trip generation rates. The residuals from the multiple regression model (Figure 19) reveal one distinct outlier ($Y_1 = 38.3$, $\hat{Y}_1 = 56.1$). This particular mill has characteristics which distinguish it from the others:

(a) It has significantly lower productivity per employee than other mills. This might be because;

(b) It is a purely cedar-producing mill; cedar lumber is a relatively high value commodity compared with other species produced in coastal B.C. However, other mills included in this survey specialize in cedar. A more likely reason for low productivity is the mill's location - it is the only mill in this survey outside the urban area and it is situated on the Fraser River some 30 miles east of downtown Vancouver. A non-urban, location may be devoid of some diseconomies of urbanization, the higher costs of land and labour for example. A greater labour input might be substituted for capital investment.

(c) This mill is the only case of a sawmill providing its own transportation to the market. For reasons discussed earlier, the firm controlling the transportation

Figure 19:
Residuals from Regression:
Sawmills (without two largest
trip generators)



of its product has opportunities to increase load factors not available to other firms.

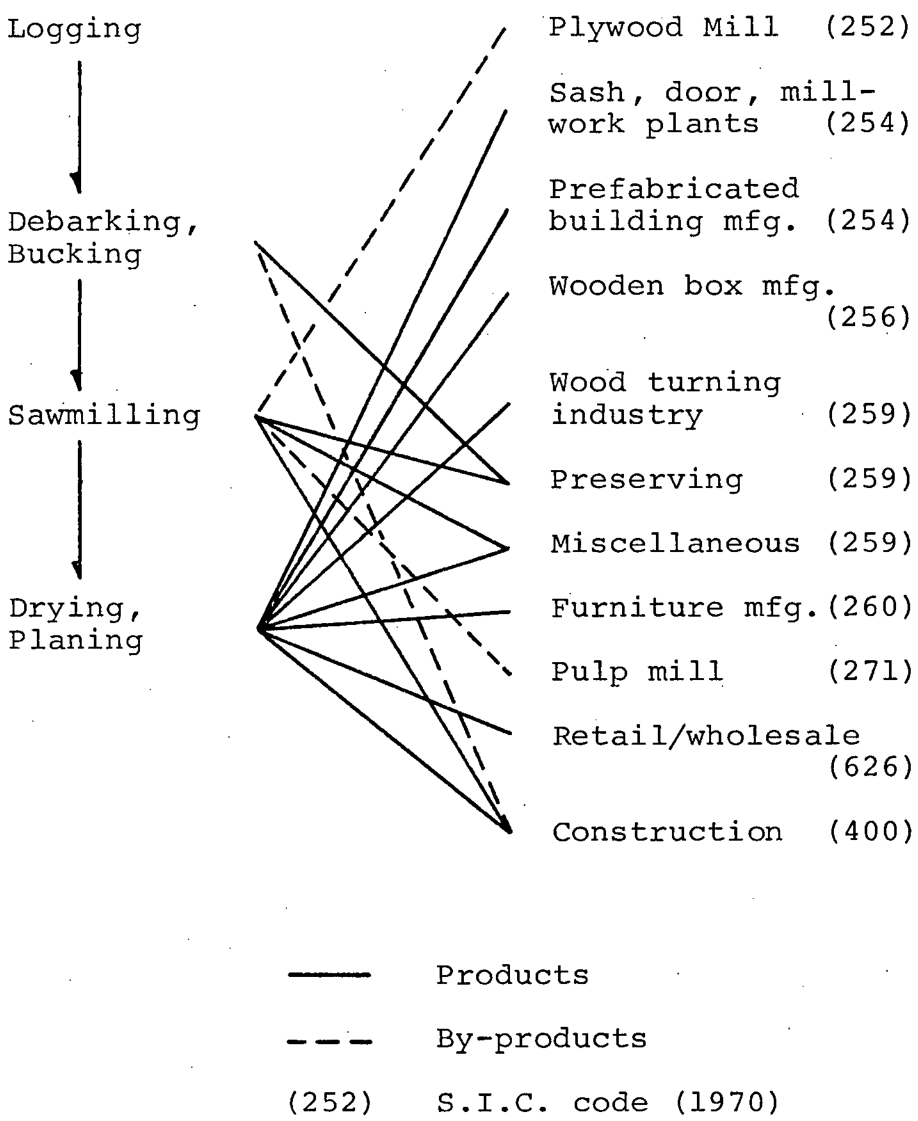
With a larger number of plants in this sample, it would be possible to use dummy variables to represent these characteristics, especially those relating to location and transportation ownership.

The introduction of a distribution channel variable makes some improvement in our ability to predict trip generation rates. In order to understand why this should be so, channels available to sawmills will be discussed in more detail.

Distribution Channel-Trip Generation Relationships: Sawmills

The sawmill-centered activity system is defined in Figure 20. The classification of sawmill customers used was based on both observation of the data and a priori expectation. The left side of the chart contains the activities which normally occur in one sawmill site - stripping the logs of bark, bucking to appropriate lengths for the sawmill, sawmilling (cutting the log into standard sizes of lumber), drying (either kiln or open air), and planing, with further cutting, trimming and planing to the dimensions demanded on the market. Two classes of operation, drying and planing, are sometimes performed at separate sites. As the structure of the industry is changing to one of fewer and larger plants, this spatial separation activities is decreasing. However, there are still a large number of small plants whose foothold

Figure 20: Product Linkages, Sawmill Activity System



in the market depends on their ability to supply a specialized product or service. An example is one of the plants surveyed under "miscellaneous" which has an extremely high trip generation rate per employee. Such an extraordinary demand for transportation can only be explained in terms of the plant's market: it serves only construction sites and provides lumber cut for immediate on-site use. This is a service not normally provided by the major sawmills which form the core of the surveyed plants. The larger mills generally prefer not to market their product direct to the construction industry because of its poor credit rating. The extension of credit is one of the means by which small mills and most wholesalers retain a share of the market. The construction industry, especially residential construction, is characterized by many small firms nearly all of which are devoid of power in the marketing channel and whose smallness and scale of operating unit mitigates against bulk ordering and on-site inventories. These factors contribute towards high trip generation rates for those mills and remanufacturers whose market is dominated by construction customers.

Other small mills providing a specialized product or service include those which produce the raw material for the turning industry, or wood otherwise cut to final-use dimensions - fencing materials, custom cut lumber, and interior decorative products, for example. Many of these firms have characteristics similar to those of sash, door, and millwork plants since they are significant trip attractors from major sawmills and produce a product whose main local use is in construction and is either marketed directly to the industry or through local retailers and wholesalers.

These small mills are not shown as a distinct activity in Figure 20 but they are significantly linked to the larger mills. Tables 6 and 7, which itemized market shares by plant for major sawmill customer types indicate the significance of linkages to other sawmills. Second in importance in shipments and trips to remanufacturers are those to millwork plants. Other manufacturers constitute an insignificant market for most sawmills surveyed, because of the importance of interaction between smaller sawmills and millwork plants and other activities such as pre-fabricating buildings, furniture making, wood-turning, etc. An extended survey or complete transportation study would naturally include research into these linkages between small plants.

Construction firms are classified separately in the chart of product linkages, although the main sources of supply of lumber and plywood for the construction industry are not direct mill to site sales. This raises the problem of classifying retail/wholesaleinstitutions in the channel. Unlike manufacturers, many commercial firms act as an intermediary between producer and consumer of wood products without taking physical possession of the product. The extent to which this is the case on the local market can be judged by examining the classification of retail/wholesale used in

Tables 6 and 7. One of the criteria for distinguishing between types of retailer is the amount and type of wholesaling done by the firm. Wholesaling is defined for this purpose as buying merchandise for resale to retailers, to industrial, commercial, institutional or professional users, to other wholesalers, or in acting as agents in connection with such transactions. Establishments in the retail trade buy commodities for resale to the general public for personal or household consumption. The significance of this distinction for transportation demand is that wholesalers sort the commodities they buy prior to acquisition by retailers and institutions other than individual consumers; this sorting of goods is normally less "fine" than that which occurs in retailing. The commodities bought by the wholesaler normally have greater bulk, less individual packaging, and lower per unit prices than those bought by the retailer. The wholesaler located at a distance from the source of a commodity frequently performs the function of postponing the spatial sort, thus assuring the manufacturer of a distinct market at a higher per unit price than would be possible if shipments were made directly to final users. This is the role performed by the large wholesalers of wood products in the eastern Canadian and U. S. markets, although the larger manufacturers in B.C. have recently tended to take over this wholesale function by establishing their own sales branches and warehouses at distant major markets. In either case, the existence of a wholesaling activity with greater proximity to the final market permits the use of rail or water transportation, which naturally lowers truck trip generation rates.

In the case of markets closer to the point of production, the role of the wholesaler may remain essentially the same, although the nature of transportation demands may change. For the B.C. market outside the urban region (Greater Vancouver and its region) direct truck, or truck plus some other mode of transport, is normally the most economical means of reaching the market. This is because of the spatial diversity of demand for wood products in the rest of B.C.: no one spatially distinct market has a sufficient volume of demand to support a large and regular movement of rail traffic and more sorting of the commodity takes place at the point of production than was the case above. The wholesaler's role in provincial transactions may be one or several of: providing information to the retailer, taking physical possession of the commodity and transporting it to the market, taking only ownership possession of the commodity and arranging its transportation, providing credit to the retailer or other small volume customers and making payment to the manufacturer.

In the local market for the product, the role of the wholesaler (at least in the wood products industry) is declining. Increasingly transactions and transportation are direct to the retailer and other end users either directly from the mill or through a local sales distribution outlet owned or controlled by the manufacturer. As was noted previously, wholesalers of wood products in the local area do perform an important role in providing credit to their customers. They are also a source of information, stocks and an increased variety of commodities over those available from any one mill. The most important customers for local wholesaling activity are those in the construction industry.

Shipments to contractors usually appear on plant records as sales to wholesalers, and information on the distribution of trips is lost unless driver delivery slips are available. This does not negate the use of distribution channel structures in causal analysis since a sale to and shipments by a wholesaler might still be expected to have characteristics different from transactions with and movements to retail or construction sites. Wholesalers whose foothold in the market is maintained by their ability to provide services such as information and extended credit, or products more closely in line with customer needs, might also be expected to provide the service of good transportation. Trip generation rates for such an activity may be high relative to the mean for all retail/wholesale outlets for mill products. This is probably most true for "office wholesalers" - those wholesalers who do not take physical possession of the product they sell, but do arrange financial transactions and other services mentioned above. Office wholesalers serving only the local market are not very significant, although many retailers and wholesalers may perform office wholesaling functions where the need arises. Most local wholesaling is "with stocks", i.e., the wholesaler takes physical and ownership possession of the commodity and maintains an inventory. Shipments which enter inventory are likely to be of greater bulk and weight than those leaving the inventory, given that the storage functions can also be associated with an allocation sort.

In summary, therefore, inclusion of a marketing variable - in this case the relative importance of the retailer and wholesaler - does improve our ability to statistically estimate the number of vehicle movements from a manufacturing site. A more detailed analysis of the structure of distribution channels and the behaviour of firms enables a partial explanation of why the activity at a trip's destination is related to the frequency of trip-making at its origin. As explained earlier in this study, in the chapter which provided the theoretical foundation of a marketing model of transport demand, these trip frequencies are directly related to shipment size and the nature of transport supply. This direct relationship is examined in more detail in the following section.

Shipment Size and Truck Capacity: Sawmill Shipments

Over shorter time periods, say of one month or less, a retailer is less reliant on any one manufacturer than is the re-manufacturer. He can afford to wait for favorable price changes, or encourage sales in substitute products, rather than ship from the manufacturer at a volume and frequency predestined by a production schedule.

Local manufacturers have lower inventory costs per unit of lumber or plywood than local retailers because:

(1) Higher re-manufacturing sales volumes between individual pairs of manufacturers and re-manufacturers as opposed to manufacturers and retailers leads to stronger locational linkages between the former groups of pairs. This, in combination with the market-orientation of lumber and plywood retail locations, leads to a common tendency for re-manufacturers to locate close to their sources of supply. These locations tend to be characterized by lower land values and greater space available for storage than is typical of retail locations.

(2) At retail outlets, wood products compete with other products - usually higher valued items - for inventory space. The costs of storing wood products must either be offset by a very high turnover in sales, or decreased by ordering (less than truck-loads) LTL shipments. The latter course increases transportation and ordering costs, but given the rise in retail land values at locations where sales may be maximized and the strong competition for space from metal and plastic substitutes, the high costs of LTL shipment and low EOQ (economic order quantity) are likely

to be sacrificed for like advantages of lowering industry costs.

A consequence of behaviour with respect to inventories and EOQ appears to be a tendency for retailers to provide their own transportation (PMT) and for re-manufacturers to use for hire or contract carriage. Other factors are important as well, notably the use that the retailer makes of private trucks for delivery to his customers and the reluctance of the remanufacturer to commit himself to ownership of one or two heavy haulage units. Once the decision has been made by the retailer to own PMT, there is a reduction in his incentive to reduce transportation costs by economizing on the rate of trip making or the number of ton-miles consumed over time. The reason for this is that by owning PMT the retailer has assumed substantial fixed costs which, as we have seen, can probably be better offset by reducing inventories than minimizing variable costs of transportation. The re-manufacturer, in cases where PMT is not present, has a transportation outlay equal to the sum of the prices charged by the carrier for each trip made. The incentive here is to reduce the number of trips from sources of supply by maximizing load factors on the carrier's vehicles. Of course, this argument is only relevant to the extent to which retail/wholesale activities own trucks and re-manufacturers do not.

Tables 6 and 7 at the beginning of this chapter may be used to compare the percentage of total local quantity of product with the percentage of total local trips from each mill to various distribution channel participants. As expected, there is a general tendency for the percentage of quantity shipped to other manufacturers to be higher than the percentage of trips, i.e. shipments to manufacturers tend to be larger than to other destinations.

A comparison of shipment-size frequencies of all shipments from all sawmills to their local customers demonstrates the different behaviours of retailers and remanufacturers. Figure 21 shows a strong grouping of shipment-sizes to other sawmills around 6000-9000 FBM and around 11,000-12,000 FBM. A similar situation exists for millwork plants, although with a slightly greater grouping in the lower shipment-size categories. This marginal difference on the part of millwork plants is due to their greater willingness to sacrific transportation costs for lower inventory costs: in contrast to sawmills, most millwork raw materials and products require indoor storage and more careful handling.

Figure 22 is composed of three parts, each part being designed for cross-reference with the other two. Figure 22a, the size distribution of retail/wholesale shipments, shows marked differences between size categories. The most significant concentrations are in the sizes 5000-8000 and 9000-11000 FBM (Figure 22a).

Figure 21: Number of Trips by Size of Shipment: Sawmills

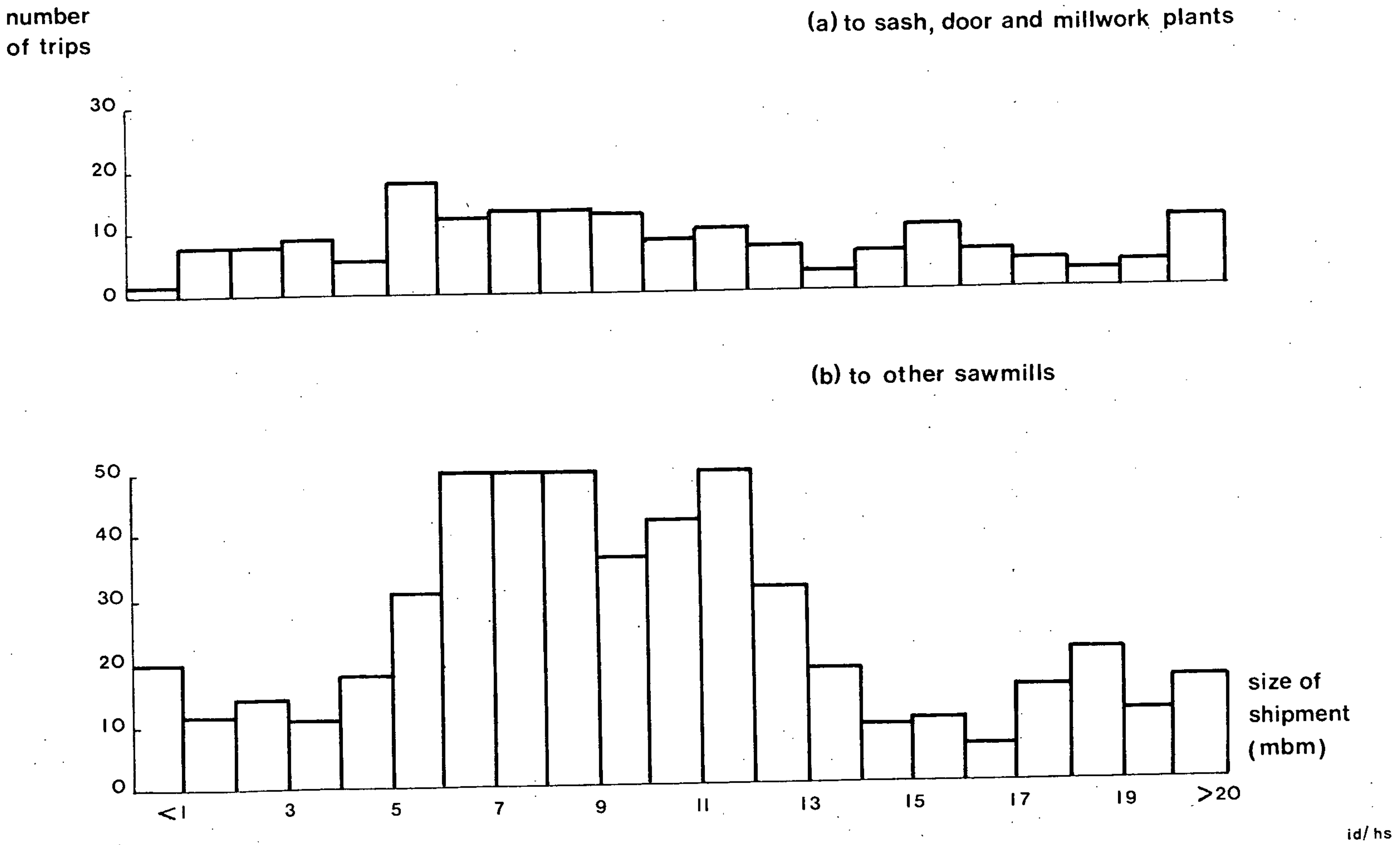
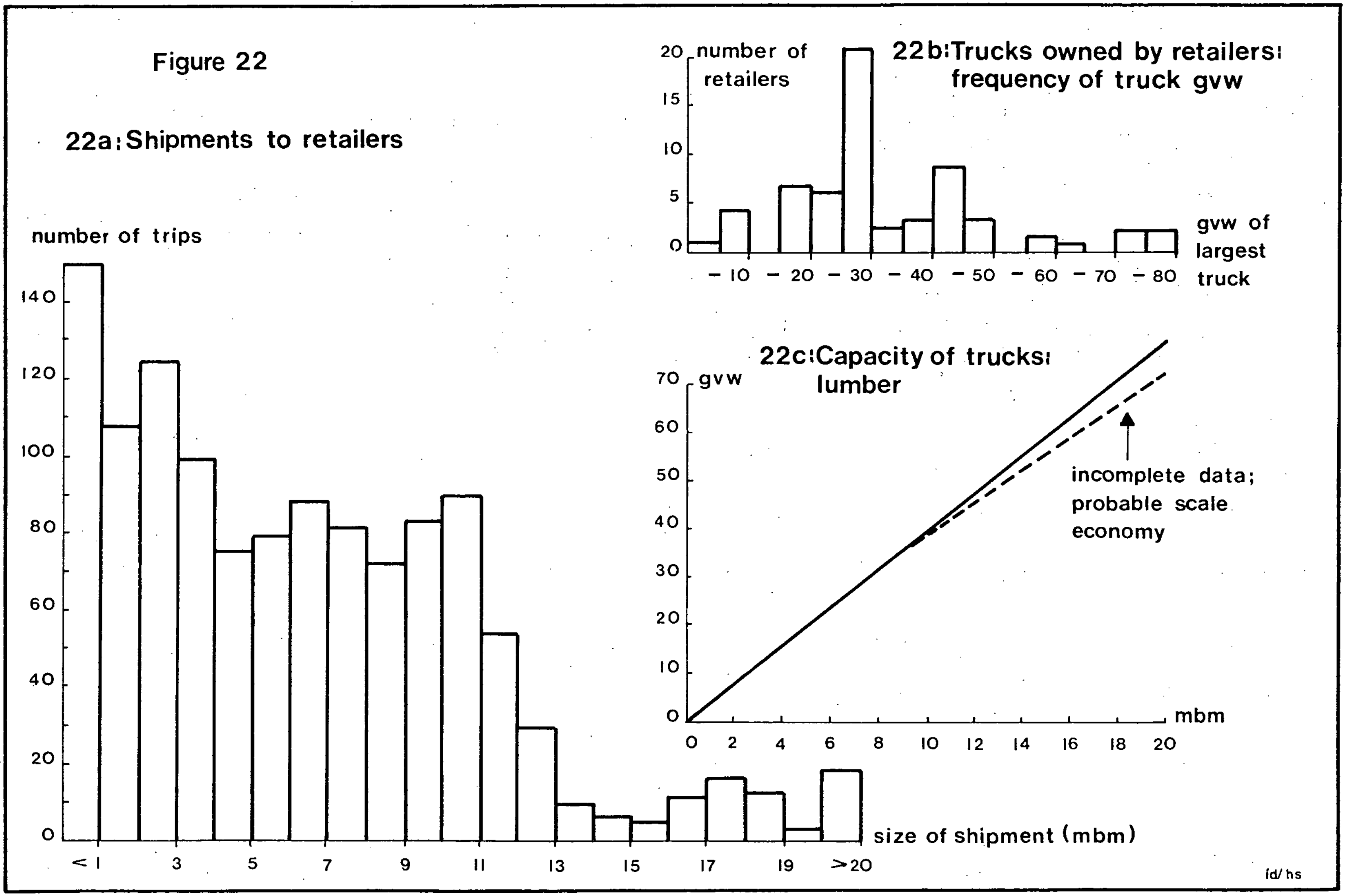


Figure 22



22a: Shipments to retailers
number of trips
size of shipment (mbm)
22b: Trucks owned by retailers: frequency of truck gvw
number of retailers
gvw of largest truck
22c: Capacity of trucks: lumber
gvw
mbm
incomplete data; probable scale economy
fd/hs

Figure 22c presents a rough guide to the lumber capacity of trucks by (GVD) Gross Vehicle Weight.[1] Part of the retail survey, which will be analysed in more detail in the following chapter, asked of each retailer to whom any of the sawmills surveyed made shipments the following information: (a) GVW of each truck owned and (b) FBM capacity of each truck. Figure 22c shows a linear relationship between these two variables, although in fact there is probably some slight non-linearity due to technological economies of scale. Larger trucks do have slightly higher weight capacities than smaller ones per unit of GVW, but the difference is so minor it has been omitted for the sake of simplicity.

Figure 22b shows the frequency of GVW's of each retailers' largest truck, which was selected on the premise that the largest truck is most likely to be used for shipments from sawmills, while smaller vehicles, if any, are more likely to be used for retail/wholesale delivery after the product sort has taken place at the retail/wholesale inventory.

Figures 22b and 22c may be used in conjunction to estimate the FBM capacity of vehicles owned by retailer and wholesalers. The greatest concentrations are around 26000 and 44000 GVW trucks, (Figure 22b) which have respective

---

[1] Gross Vehicle Weight (GVW): weight of vehicle plus load when loaded to weight capacity limit.

capacities of about 6000 and 1000 FBM. As can be seen from the histograms, this coincides with the most frequent shipment sizes for sawmills in Figure 21, although truck GVW for shipments to other sawmills is unknown as the industry tends to use for-hire or contract carriage. The 6,000 and 11,000 FBM size categories are also significant in shipments to retailers (Figure 22a), although not as dominant as less-than-4000 FBM shipments. About 8% of the largest vehicles of retailers are below 15000 lbs. GVW. A truck of 15000 GVW holds approximate 4000 FBM of lumber. Shipments below 4000 FBM account for almost 40% of all shipments surveyed. Were these percentages closer, there would be a possibility that those trucks below 15000 GVW might be loaded to capacity and merely make more frequent trips. However, the evidence is that LTL shipments are common among retail/wholesale activities, in striking contrast to the case of shipments to re-manufacturers.

An analysis of the frequency of shipment-sizes has emphasized the importance of differences in transportation behaviour between re-manufacturing and other (commercial) institutions in the total activity system. The generally lower truck capacities available to retailers and wholesalers obviously has a significant effect on the number of trips made to these customers of manufacturers. Before investigating in greater detail the role of retail/wholesale characteristics in influencing trip attraction rates to commercial sites, a brief discussion of the factors influencing trip generation rates at non-sawmill sites is warranted.

Distribution Channel - Trip Generation Relationships: Other Manufacturing Sites

We have seen that the statistical estimation of trip generation rates can be improved by incorporating a marketing variable, and it has been explained why this should be so for the twenty sawmills surveyed. The discussion below considers, on a plant-by-plant basis, the marketing characteristics of a miscellaneous group of wood products manufacturers as they influence transport demand.

A qualitative approach is taken in this discussion because the detailed attributes of miscellaneous wood products manufacturing sites illustrate the effect of industrial structure and distribution channels on trip generation and attraction rates, which in turn focus on the unique attributes of firms in the sample. The complexity of channel structure and functions at this level of disaggregation renders the more formal approach based on a multiple regression model largely meaningless since the most interesting aspects of physical distribution and transportation demand would be concealed. All the plants in the following discussion are located on or close to the Fraser River in the same area as the bulk of the sawmills surveyed.

Millwork Plant: branch of major forest products company. This plant is of average size for those producing mouldings, doors, etc. but is distinct in that it produces mainly for the non-local market. This is the result of a marketing decision by the parent company: not to compete on the local market but to distribute the product through the marketing organization available for the main company products (lumber and plywood) in order to reach customers beyond the more limited marketing organizations of other local producers. The result is that this plant has a typical trip attraction rate (truck load shipments averaging 10000 FBM) from local sawmills (other branches of the parent company) of approximately 5 trips per day in the month surveyed. Because only 10% of monthly production is sold on the local market, however, the local trip generation rate is about one trip per day, the shipment-size frequently being less than 1000 FBM. <u>Millwork Plant: Independent</u>. With about one third of the employment at the previous plant (13 instead of 36 employees) this plant markets substantially more of its production on the local market (75%) and consequently generates an average of two trips per day. Most local shipments are through brokers to construction sites. Shipments to wholesalers retaining some stocks tend to be larger than those direct to the construction site although this is the manufacturers claim and no data was provided to support it. The 25% of the market which is non-local is in the Prairies and is supplied in 30000 FBM truck loads. As in the case of the previous plant, this non-local sector of the market causes the trip attraction rate to be higher than that of trip generation, though the difference between the two rates is minor for this firm.

Construction Millwork Plant: Independent. The significant difference between this plant and the two previous cases is the great variation in trip generation rates throughout the year. The reason for this is that the plant manufacturers millwork products but also installs them at construction sites, relying solely on this method of marketing. Production activity at the site is therefore highly dependent on current or pending contracts. Data were available on trip generation rates ranging from highs of three trips per day in some months to almost zero in others. Another problem with this type of firm is the difficulty of distinguishing between production and off-site (installation) employees.

Sawmill (construction): This plant has been mentioned before; it processes locally produced lumber into customer cut dimensions and ships them direct to construction sites. Trip generation rates are very high, greater than attraction rates since all the product is marketed locally. This and the previous millwork plant exhibit the distinctive trip generation attributes of those plants which perform almost the entire inventory function between mill and end use: these are high trip generation rates during periods of construction activity and great variability over the year. The demand for transportation at the site, in other words, is undampened by the performance characteristics of intervening retail/wholesale functions.

Piling manufacturer: poles and pillings, treated with preservatives, find their main uses in heavy construction for utilities and public works. Since most of this activity is located in the less-developed regions of British Columbia, and product is bulky and of low value, most transportation is by rail and water; trip generation rates are low. As in the case of the last two firms, the inventory function in the channel is performed at the manufacturing site and the demand for transport is again a direct function of the level of construction activity.

Lumber and Plywood Treating and Preserving: Treated lumber and plywood, as opposed to logs above, finds a variety of uses in exterior construction. This plant has the most varied of backward and forward linkages, probably because it has so few competitors in western Canada and northwestern U.S.A. This lack of substantial competition can be attributed to the availability of non-wood substitutes for much of the production, and to the inability of the market to support more producers because of economies of scale in the production process. Materials are attracted to the plant from sawmills and dry kiln plants, purchased on the treating plant's own account. Other trips are attracted from wholesalers who own the product and retail ownership during the treating process. To the extent that these latter trips are LTL, the trip attraction rate to the plant is higher than the rate would be if all raw materials were purchased on own account.

As with the piling plant, a substantial amount of the product is shipped to non-local destinations, although the local uses for treated lumber and plywood are more significant. "Local uses" again refers to the identity and location of the customer in the urban region. When this customer is a wholesaler, there always exists the possibility that the product is finally consumed outside the urban region. However, much of the treated lumber and plywood appears to at least be stocked locally; such shipments may therefore be properly labelled "local".

Shingle Mill: The most dramatic case of discrepancy between plant size and truck trip generation rate is the case of a shake and/or shingle mill. This activity is peculiar to the Pacific North-West of the United States and the coast of British Columbia because of the existence of high quality western red cedar and the traditional skills in manufacturing the product. For the plant surveyed, and probably the majority of mills in this activity, over 90% of the market is in the U. S. Consequently the mill trip generation rate is low (less than one per day) despite an employment size of 170.

Laminated beam plant: This mill also has a fairly simply structured trip attraction pattern - some two or three trips per day of 20000 FBM each trip. The product however is used for a variety of construction purposes, some merely decorative. Because of a dispersed, small, and unpredictable demand for the product, the market supports few plants manufacturing laminated beams. The truck shipment pattern is widely distributed with a mean through highly variable trip generation rate of five trips per day. Although of similar weight and bulk to piling products, laminated beams tend to be shipped by truck to the non-local market. The fragility and value of the commodity is obviously a significant determinant of modal split between the two products.

Cedar Siding Mill: This mill is included in the "miscellaneous" category of plants because of the emphasis on a very high quality product. This revealed in the low productivity per employee of 170,000 FBM per employee per year compared with an average of about 300,000 FBM for the twenty sawmills. This plant specializes in distant market and uses (primarily) the sales branches of the larger forest products companies as an outlet for the product. Evidence for the importance of distant markets comes from the fact that 50% of the non-production worker employment comprises the sales force and is employed outside the Lower Mainland. Other interesting results of the specialization are: (a) the plant has the only truck-to-air freight shipment encountered in the survey, and (b) of the approximately 25% of total shipments which move by truck, nearly all are to other regions in western Canada. In spite of the shipment distances involved, the average size of each consignment is only about 200 FBM. This firm is also the only case of a wood products manufacturer, other than paper mills, which has a significant proportion of multiple-consignment shipments. For-hire inter-city carriers provide the transportation at the manufacturing site and the manufacturer organizes the shipments in a manner similar to the procedure hypothesized to be used in the shipment of local, small consignment, multiple deliveries (page 65). Inter-city trucking companies normally serve specific regions and the shipper, with this knowledge, can organise inter-city shipments in such a way as to minimize both the handling costs at the plant and the total transportation bill for the customer or himself (given the constraints imposed by quality-of-service requirements). For this siding mill, therefore, consignments are grouped as far as possible into regional destinations - Prairie shipments on one truck, northern B.C. on another, etc.

This is a unique plant in the survey, and it is impossible to test adequately the hypotheses about long-distance highway transportation which might have significance for trip generation rates. However, some factors appear to strongly influence trip generation rates, and they might be confirmed in future research -

(a) Given a high value commodity of low average EOQ, there is a strong possibility that multiple delivery shipments will occur.

(b) Given (a), and an important long-distance market, consignments will be grouped into shipments from the plant according to the division of that market into regions served by individual inter-city carriers.

(c) Given (b), trip generation rates should not vary much from the case where the market is entirely local, but trips from the plant would be distributed differently: instead of a multiple delivery pattern within the urban region this function takes place in the non-local market and trips from the plant either move directly to the appropriate market-region or to theinter-city terminal for additional load and thence to the non-local destinations. If the market were predominantly local, and the transportation were provided (as opposed to paid for) by the customer, then the plant would conform to the general sawmill model proposed.

Pallet manufacturer: In the case of this plant, almost all shipments are to manufacturers of food and industrial goods. With some eleven trips per week generated, one trip per day attracted, and only six employees, this plant is included to indicate the great variety of linkages which would be recorded were the complete wood products activity system to be analysed rather than only the major traffic generators. Despite such a plant's individual insignificance, it does serve to demonstrate the additive effect that numerous small plants can have on traffic generation within and between specified zones in the city: within less than one mile of this plant are located several other of the plants surveyed - a sawmill, a plywood mill, and two of the miscellaneous firms - and three wholesalers of wood products. If the area enclosed by these plants and firms can be thought of as a traffic zone, substantial intra-zonal transfers of raw materials for smaller manufacturers and wholesalers exist. Furthermore, since the predictive equation for trips generated by sawmills tends to be efficient for plants with distribution channels which are either retail/wholesale or to re-manufacturers ($Y_1 = -0.028 + 0.170X_1 + 0.624X_2$, X_1 = non-basic employment, X_2 = % local quantity to retail/wholesale, Y_1 = trips per week) this model loses much of its utility where the distribution channel structure is entirely different. The sawmill model predicts one trip per week instead of the eleven observed; such an error compounded for many small plants can have an adverse effect on the efficiency of the sawmill model if it is applied to all wood products manufacturers. In other words, where wood products re-manufacturers, retailers, or wholesalers do not comprise the large part of the destination of a mill's local market, but instead some other economic activity (in this case food and machinery handling) is the customer for the product, then a quite different set of transport demands may be generated.

The pallet manufacturer serves a market where order quantities are small, shipment distributions are dispersed within the urban region, and the product has high volume relative to weight. It should therefore be grouped with plants with similar characteristics, such as producers or wholesalers of machinery supplies and parts, or distributors of packing materials.

Manufacturer's Sales Branch: The major multi-plant forest products companies utilize a variety of channels for distributing their product. The decision to own or otherwise control non-local outlets for their products (Prairie and Eastern Canada warehouses and retail/wholesale outlets for example) certainly affects the price and competitive position of the companies' products, but the effect on local truck movements is negligible. Two of the six major companies, however, have taken the option of establishing greater control over the physical distribution of their products in the Greater Vancouver area and its tributary region (essentially the remainder of British Columbia). They operate a sales warehouse in the Lower Mainland just as they and other companies have similar outlets throughout much of Canada.

Control over the operations of a local sales branch is largely equivalent to taking over the wholesaling function in the channel. The costs to the manufacturer are made up of additional storage, ordering, and billing costs, an increased sales force and physical distribution capacity, and the price paid for a location in the urban area of higher accessibility to the local market and inter-city transportation terminals. However, these additional costs provide the manufacturer with a means to compete with other wholesalers of wood products by direct control over the production process and the supply and price of lumber and plywood. Competition from producers of wood products (other sawmills, etc.) is met by offering a wider range of products to the retailer, many of which are not produced by the parent company. The advantage to the retailer is that he can purchase lumber and plywood at competitive prices and with the name brand of a major producer, at the same time as he purchases a variety of other products and services essential to the complete retail operation: glues, plastic and asbestos building materials, product information, architectural and design ideas, etc.

The impact of a manufacturer's sales branch on trip generation rates at the mill is slight because the sales branch behaves in a way similar to other wholesalers with respect to EOQ. There appeared to be a tendency towards higher load factors and shipment-sizes, although the desire of the company to minimize inventory costs apparently caused little concern for the costs of transportation from mill to sales branch. The most important implication is for the mills' trip distribution pattern. Manufacturers with their own assured wholesale outlet ship all but overseas export consignments to the sales branch, resulting in a distinct concentration of truck movements along one route. The dispersed pattern of movements typical of mills which serve many remanufacturing and retail/wholesale outlets is not present; this stage of distribution is carried out by the sales branch, which has a large numberof trips generated per day. The impact of vertical integration within the channel on the spatial distribution of trips is therefore significant enough to justify its inclusion in a larger goods movement and transportation study.

Trip Generation and the Effects of Marketing Variables: Conclusions from the Wood Products Industry Analysis.

Despite the fact that improved estimates of trip generation rates may be obtained by including distribution channel variables in predictive equations, there should still be a suspicion that the regression results are influenced by a few exceptionally large manufacturers. During the summary below of the regression results which were obtained, the two sawmills with large (greater than one hundred trips per week) truck transport demand are omitted for purposes of comparison.

Using the following notations

Y_1 = local trips

Y_t = total trips

X_1 = non-basic employment

X_2 = % of total local shipments, by weight, to retail/wholesale customers

X_t = total employment

Q_1 = quantity shipped to local market

Q_t = total quantity shipped.

these results were obtained for the twenty sawmills:

$$Y_1 = 6.62 + 0.717\ X_1 \qquad (r^2 = 0.710)$$

or, omitting the two exceptionally large firms,

$$Y_1 = 9.509 + 0.599\ X_1 \qquad (r^2 = 0.489),$$

and
$$Y_1 = -12.295 + 0.355\ X_1 + 0.721\ X_2 \qquad (r^2 = 0.798)$$

or, omitting the same two firms;

$$Y_1 = -0.028 + 0.170\ X_1 + 0.624\ X_2 \qquad (r^2 = 0.562).$$

This is an improvement over;

$$Y_t = 19.34 + 0.113\ X_t \qquad (r^2 = 0.32)$$

and $$Y_1 = 14.50 + 0.110\ X_t \qquad (r^2 = 0.33),$$

which conform to the plant-size model.

The exclusion of exceptionally large plants from the equations yields the interesting conclusion that the results of regression analysis must be viewed with great caution. Doubt can be cast upon the results of previous studies which have not taken the precaution of testing the sensitivity of coefficients to one or two exceptionally large values.

It is interesting to note that for

$Y_1 = 6.54 + 0.107\ X_t + 0.163\ X_2$, $r^2 = 0.35$. The addition of a local marketing activity variable is only significant once the employment variable has been adjusted to eliminate the effect of basic economic activity - at least in the case of this industry, sawmilling.

It must be remembered that X_1 is itself a marketing variable, since it is derived from locational information about shipments. The assumption that "local" is within the Lower Fraser Valley is to assume that there is no modal split in this area, which is true almost without exception. Such a simple definition of local may well be impossible in other regions of Canada, especially the Windsor-Quebec Corridor. In that case, more complex distance functions might be appropriate, but it is equally likely that the characteristics of customers may take on renewed significance. For example, if, within one distance range, some of a plant's output is shipped by truck and some by rail (and assume an equal availability of truck and rail, and a single commodity is produced), then the decision by which mode to ship is determined by the customer's requirements: level of service and shipment size, which as we have seen vary by customer activity.

The significance of the percentage of shipments going to retail outlets is due to the fact that they are, overall, lower in size than those destined for local remanufacturers. Lower shipment sizes can in turn be traced to less inventory space available, competition for inventory space with more valuable commodities, and lower vehicle capacities. The last is probably as much a result as a cause of smaller shipment sizes. If so, knowledge of trends in inventory space will be more important and easier to incorporate as a predictor of future trip generation rates than those of truck capacity. To the extent that lumber retailing is becoming concentrated in suburban, large lot, "factory warehouse" sites, average shipment sizes will increase. With the present amount of available truck capacity this may result mainly in an increase of truck-load shipments, not a corresponding increase in truck movements.

Finally, several further conclusions may be drawn by observing the association between plant, market, and tripmaking characteristics at a variety of miscellaneous wood products manufacturers. Many of these detailed observations point to the need for further efforts to measure more fully the complex marketing-transportation relationships. At the moment, several conclusions may be reached from the observations about miscellaneous trip generators:

(1) The proportion of total shipments which are marketed locally is important for most plants, although the modal split problem appears to be of real significance for only those plants manufacturing or distributing higher value per unit weight commodities, or marketing their product in small consignment sizes at a distance from the plant.

(2) The more a plant's production and shipments are dependent on end-use activity levels, such as direct mill-construction site shipments, the greater the monthly variation in truck trip generation rates at the plant.

(3) If inventories are used within the distribution channel, trip generation rates are less erratic through time. A possible exception to this may occur where wholesale inventories occur at spatially discrete sites but are owned by an integrated forest products company. In this case the manufacturing and wholesaling functions are (ideally) centrally controlled; the emphasis is likely to be on minimizing inventory costs, which may not equate with minimizing shipment frequencies from mill to sales branch. This is especially true where the company owns or leases vehicles for transferring products from mill to sales branch, since once the large fixed costs of owning or leasing vehicles are

absorbed, there is little incentive to force reduction of vehicle use in contrast to the shipper or consignee who pays for-hire rates.

(4) Small plants in the wood products activity system maintain their existence and competitive position by performing specialized services or producing commodities for which the demand is widespread but the consignment size is small. Many of these plants would appear to be better classified into other activity systems such as "industrial goods production and installation".

(5) Plants should preferrably be grouped according to distribution channel used rather than raw materials processed. Where a wood product manufacturer serves an entirely different market from wood product retailer, wholesaler, or manufacturer, the truck trip estimating procedure collapses.

The retail/wholesale market has been a focus for this first attempt at a causally structured analysis of manufacturing trip generation rates. Since the data set comprises the forward linkages of manufacturers, we can equally well discuss retailers in their role as trip attractors.

CHAPTER VIII

RETAIL TRIP ATTRACTION RATES

This chapter analyzes retail site trip attraction rates, which are hypothesized to be responsive to a similar set of factors to those encountered in the study of sawmill trip generation rates. These factors are:

(1) Size of the site: for example, number of employees at the retail site.

(2) Function of the site: in the case of sawmills, this factor was assumed to be homogeneous, that is to say all mills produced lumber. For retailers, however, site function should become a variable: retailers vary in the significance of lumber to their total output, and vary in the degree to which they wholesale or retail their output.

(3) Characteristics of the market: the "market" referred to for retail trip attraction is the source of supply, that is the origins of trips rather than their destinations. The number of these supply sources (i.e. sawmills) and their distance should be related to the number of trips the retailer makes to obtain his supply of lumber.

(4) Transport supply: i.e. who owns the trucks moving the commodity from manufacturer to retailer, and the capacity of these vehicles.

This set of factors derives directly from the discussion in Chapter IV on the theoretical foundations of a marketing model of truck transport demand. From an urban transport planning viewpoint, the subject of retail trip attraction is more important than the issue of trip generation from manufacturing sites, since traffic congestion is a greater problem in commercial areas than in industrial districts. The reason for this, of course, is to be found in the spatial structure of cities: commercial areas, which are made up primarily of retail and service activities, tend to be spatially associated with concentrations of urban population. It is in such areas that truck traffic comes into the greatest conflict with pedestrian, automobile, and public transit traffic.

Methodologically, however, the analysis of retail truck trip attraction nicely complements that of industrial trip generation for two reasons. First, conceptually, retail trip attraction rates are closely related to the trip generation rates of their suppliers, whether these be manufacturing plants, wholesalers, or intercity transport companies. The only exception to this occurs where multiple delivery shipments from suppliers are common; for example a truck-load from a manufacturer may have its contents destined for several retailers. Secondly, the type of data required to construct a marketing model of trip generation rates from manufacturing sites also creates a data base on trips attracted to the manufacturers' customers. In the survey of Vancouver area wood products manufacturers, for example, the single data collection procedure of recording information from the plant's invoices and driver delivery slips provided data which are normally collected by a survey of both the manufacturer and his customer.

In order to study retail trip attraction rates we need more information about the retailer than simply his identity and location. Extending the argument set forth in the discussion of distribution channels and transport demand (Chapter IV) and the marketing model of sawmill trip generation rates (Chapter VII), marketing and activity information is required from each retailer. In the first sub-section which follows, these data requirements and their method of calculation and collection are discussed. The data analysis is then divided into three parts:

(a) The magnitudes of significant linkages (defined as greater than one trip per week) between pairs of manufacturers and retailers are estimated from variables which include trip distance, shipment size, the importance of lumber to the retailer, retail firm size, and truck capacity.

(b) Trip attraction rates for retailers are estimated from a similar set of variables.

(c) One effect of the structure of the retail industry is also analyzed, in this case the question of retail site ownership (whether or not the site is part of a chain of stores).

The Collection and Calculation of Retail Trip Attraction Model Data

Two general sources of data were used to estimate the importance of factors influencing retail site truck trip attraction rates:

(1) The survey of sawmills collected data which were used in earlier chapters to estimate trip generation rates for manufacturing plants. For the subject of this chapter - the transport demand of retailers - the following data were available from the original sawmill survey: the identity and location of individual retail customers, number of trips in one month between pairs of manufacturers and retailers, the size of shipment on each trip, and, by calculation, the distance between each retailer and manufacturer.

(2) A set of marketing data had to be created to supplement the sawmill-survey data. These new data are those which pertain directly to the retailer's characteristics, and they were obtained by a telephone survey of all the local retailers who are customers of the twenty sawmills originally surveyed. Refusals to provide information were followed up by personal visits to the retail sites in question in order to request the information and/or conduct visual measurements. As in the case of the sawmill survey, this investigation of retailing activity was conducted solely by this author. Ninety-two (92) retailers were surveyed in all. Not only does this total comprise all the local retail

customers of all twenty sawmills, it also coincides with the total number of lumber retail outlets in the Lower Mainland of British Columbia.

The data used in the statistical analysis of retail trip attraction rates will now be considered in detail, taking into account not only the problems of defining each variable but also its hypothesized role in influencing transport demand.

1. Trip attraction rates to retail land uses. This was calculated from the sawmill survey data, and so it includes only those trips carrying lumber from the twenty mills surveyed. The truck trip attraction rate for each retailer is defined as:

$$Y_i = \sum_{j}^{J} Y_{ji}$$

where:

Y_i = the trip attraction rate of the ith retailer with respect to J trip generators.

Y_{ji} = the trip generation rate of the jth trip generator to the ith retailer.

J = the twenty sawmills in the trip generation survey.

Of course, the estimate of the true number of lumber-carrying truck trips to each retailer is constrained by the degree to which the true value of J (thenumber of sawmill suppliers) is known. The twenty sawmills are the total population of local sawmill suppliers, but other trucks carrying lumber certainly supply many of these retailers. Other wood product trips might be expected from sawmills outside the Vancouver region, plywood and panel mills, millwork producers, and a variety of miscellaneous wood products manufacturers.

Unfortunately we have no knowledge of the extent to which interactions occur between trip frequencies from different activity systems. Apart from the fact that a retail outlet may exhibit multiple pick-up trip attractions, it is probable that the volume of trip-making from any one supplier is influenced by the combined volumes from all other suppliers. This interaction is caused by the availability of vehicles, the range of load capacities of these vehicles, and the distribution of trip ends (commodity origins). This whole problem of behaviour within firms and plants is beyond our current concern, although it would appear to be the next area for research after systematic and working models of urban goods movement are constructed using summary statistics for individual plants.

(2) <u>Average FBM on each shipment to the retailer</u>: this is derived directly from the trip generation information obtained from mills. It will be recalled that each shipment purchased by the retail categories defined, excepting office wholesale, is assumed to move directly to the retail site without a change in volume due to multiple pick up or delivery activity en route.

(3) <u>Weighted distance to source of supply</u>: one value which summarizes the distance between the retailer and his source

of lumber supply is required. A system of weighting distances between the retailer and each manufacturer was employed. This system gives greater significance and weight to distances over frequently travelled linkages, and relatively less importance to linkages characterized by infrequent trips.

Weighted distance between each retailer and sawmills supplying lumber is therefore defined as:

$$D_w = \frac{\sum_{1}^{J} (d_{ij} \cdot n_{ij})}{\sum_{1}^{J} n_{ij}}$$

where:

D_w = weighted distance of total trip attractions to each retailer;.

d_{ij} = distance from jth trip generator to retailer i.

n_{ij} = total number of trips counted between jth sawmill and i over any period of time.

Weighted distance has been defined, but mention should be made of the method for estimating each d_{ij}. Distance can be measured in a variety of ways. Linear distance can be combined with other measures of space, time, and quantity to give indices of accessibility, miles per hour, ton-miles, etc. Distance per se in transportation studies is significant only as a cost to be met and overcome, so we can assume that if linear distance cannot be regarded as a variable of significance to the problem at hand, then there may be no need to develop a theory incorporating more complex indices which combine distance and some other measure significant to transportation supply and demand at points in space. The consequence of such an assumption, which is open to more dispute than perhaps any other made in this chapter, is that location (for which accessibility is defined) and speed (the effect of highway quality and the degree of competition for road space) do not affect trip generation or attraction rates. An analysis of trip distribution cannot, of course, avoid such distance-related measures. The effect of distance in which we are interested here is its relationship to shipments sizes between any pair of locations, and the resulting effect of trip frequencies between those locations.

Three alternative ways of calculating each d_{ij} were considered:

(1) Straight-line distance (${}_s d_{ij}$). This value is calculated by:

$${}_s d_{ij} = ((a_i - c_j)^2 + (b_i - d_j)^2)^{\frac{1}{2}}$$

where grid coordinates of i and j are a_i, b_i and c_j, d_j.

(2) Grid or rectangular distance (${}_g d_{ij}$)

$${}_g d_{ij} = (a_i - c_j) + (b_i - d_j)$$

(3) Real distance (R) is some function of (1) and (2) above, in recognition of the fact that city street systems commonly exhibit networks which combine straight-line and grid routes, i.e. ${}_s d_{ij} \leq R \leq {}_g d_{ij}$. In a rectilinear street system,

$$R = q \cdot {}_{s}d_{ij}, \qquad \text{where } 1.00 \leq q \leq \sqrt{2.00}$$

Nordbeck found the value of q to be approximately 1.21 for two towns in Sweden, although he failed to point out the circumstances in which ${}_{g}d_{ij}$ might be a more efficient measure.[1] The Swedish street networks bore no resemblance to the grid systems characteristic of most North American cities. For the latter type a constant expansion factor of greater than 1.21 might be necessary. Nordbeck's method is assumed to be inadequate here because of the nature of errors introduced by using a constant expansion factor q to be applied to all ${}_{s}d_{ij}$ in the urban area. Despite his claim that an error in one distance is likely to be cancelled by an error in another, in fact errors will be compounded along specific routes. Although this criticism can be levelled at all three methods of estimating distance, we can expect ${}_{g}d_{ij}$ to be a more efficient estimate where much of the intra-urban travel is known to be along arterial routes which are part of the rectilinear street system. Ingram used this argument in his study of accessibility in southern Ontario cities. While he used grid distances, and defended their effectiveness, Ingram also noted that straight-line distances might be sufficient in other cities or in regional studies.[2]

---

[1]Nordbeck, S. "Computing Distances in Road Nets," Papers and Proceedings of the Regional Science Association, 12 (1964), 207-220.

[2]Ingram, D. R. "The Concept of Accessibility: A Search for an Operational Form", Regional Studies, 5 (1971), 101-107.

Whichever method is used, a system of coordinates has to be developed. A half-mile grid was superimposed on the map of the urban region (Vancouver and the Fraser Valley 80 miles to the east). ${}_{g}d_{ij}$ was calculated for each shipment for sawmills to retailers, and a real-distance test of some 20 of these distances proved their remarkable accuracy for all links except those where a detour to cross a body of water was required.

The magnitude and the number of errors introduced by natural barriers to movement was not large enough to justify further adjustments to the rectilinear measures. All three measures outlined above are equally simple to compute, but it is suspected that a computer program to adjust for the crossing of bridges in cities like Vancouver would be a useful device if available in the future.

In this study, grid distances were based on a half-mile grid unadjusted for bridges and other disturbances. Locations of establishments are accurate to within $\sqrt{\frac{1}{2}}/2$ ml. Distances are accurate to within 1 ml., assuming a perfect rectilinear street system.

(4) <u>Total number of suppliers to each retailer</u>: this value was calculated by simply summing the number of sawmills supplying each retailer. It is therefore always equal to or less than twenty.

In addition to the above variables which were calculated from the sawmill survey data, four more variables were obtained from the survey of retailers. These additional data, variables (5) through (8), are defined below.

(5) Number of employees at the retail site: The distinction was not made between "production" and other employees as it was for manufacturing sites, although for retail activities with a wide size distribution of firms and sites such a distinction becomes increasingly important (in food or general merchandise retailing for example). For the largest of retailers, the functions performed within the firm become spatially distinct: purchasing, accounting, and advertising activities may well locate at a different site from the location of the retailing activity. This is certainly true with respect to "chain" retailing, which will be discussed later. Number of employees is therefore defined as the average total employment at the site during 1970.

(6) Percent lumber of total stocks (by value): the second item asked of each of the ninety-two retailers was the significance of lumber to their total business by dollar value. An increase in the significance of lumber in the retailer's stock should be associated with a decrease in trip attraction rates per unit of lumber stocked because of the opportunity to increase load factors on vehicles.

(7) The percentage of lumber which is retailed to individual (private) customers: the more a business is oriented to the "cash and carry" trade, the less it is likely to specialize in any one single product or product line. The reason for

this is the market power to be gained by offering an assortment of commodities and services at one location and which best fits the needs of the market. Retail stores, as opposed to those sites and firms which offer some or all of their stocks at wholesale prices to commercial or industrial businesses, are therefore often characterized by a lower proportion of total stocks being lumber. Furthermore, we might hypothesize that the stock of lumber which is maintained at the retail site is more diverse in quality and type than at the wholesale site. This implies the existence of numerous and diverse linkages to sources of supply in those cases where the retailer is served directly by the mill. A contrast might be provided by retail backward-linkages at retail sites in eastern Canada where large wholesale outlets more often supply the sites of final retail distribution: in this case less frequent movements with higher load factors would be attracted to retail sites.

(8) <u>The Gross Vehicle Weight (GVW) of the largest truck owned by each retailer</u>: This item was obtained from each retailer in the survey. It is assumed in this study that the largest vehicle owned by the retailer is used for transporting wood products from suppliers, while smaller trucks, if any are owned, are used for picking up other hardware supplies and for all deliveries. The assumed desire of those firms paying for the transportation of the product to minimize the number of trips implies that larger

truck capacity allows fewer trips per unit time. Again, we have no knowledge of the extent to which largest trucks are actually used for picking up wood product supplies, or knowledge of the importance of for hire or contract carriage between mill and retail site. Where contract carriage is most likely to be used, that is in the transportation of the product to retail sites which do not own vehicles, it can be hypothesized that trip frequencies would be lower than average and load factors would be higher.

Two retail firms were found to operate a supply of for-hire truck transportation as part of their business. This is insignificant enough to the survey that it can be ignored. The number of employees in the firms involved was adjusted accordingly by counting only those employees in the building supply retail sector of the firms. The example does serve to indicate that merely counting total transportation capacity of a firm may give a distorted picture of the transportation capacity used by that site - up to 10 trucks may be owned and operated by a retailer or wholesaler but most of this supply probably serves a contract or for-hire transportation function for other commercial or industrial sites.

Manufacturing-Retail Linkages Greater Than One Trip per Week

The strongest trip linkages between individual pairs of manufacturers and retailers are analyzed first in the hope that this would eliminate some of the randomness which might be associated with occasional and infrequent trips. These linkages are defined as those over one trip per week. The strengths of these linkages range from 0.200 to over 2.000 trips per day, and it is these magnitudes which we wish to estimate from the data available on each trip. Since the retailer is assumed to provide the transportation, only data pertaining to the retail site is used in regression analysis.

The results are presented in Table 9. The equations do not estimate trip frequencies very successfully, the most likely reason being that the values of X_1 (trips per day) have a low range and are quite insensitive to changes in the values of $X_2 \ldots X_8$. However, it is interesting that only shipment size and distance appear to have any significance in explaining variation in trips per day. It is not clear what role distance plays: X_2 (distance) takes both positive and negative values in different equations, so there is no conclusive evidence that distance is inversely related to trip frequencies by some decay function. Mean FBM per trip is clearly the most important single variable, but it might be asked what factors determine mean FBM. Increasing trip frequency makes possible higher load factors on vehicles, but since we are trying determine trip frequencies, it makes little sense to include X_1 as a potential independent variable in an estimation of X_3.

TABLE 9

Manufacturing-Retail Linkages Greater Than One Trip per Day: Regression Equations

N = 65

Variables		Mean
Trips/day	(X_1)	0.504 trips/day
Distance	(X_2)	11.226 mls.
Mean FBM, each linkage	(X_3)	7,014.620 FBM
Number of suppliers	(X_4)	---
% lumber in retail stock	(X_5)	80.667 %
% lumber retailed	(X_6)	33.219 %
GVW largest truck	(X_7)	46,000.000 lbs.
Employees	(X_8)	14.227 employees

Equation	R^2	S.E.(X_1)
$X_1 = 0.355 + 0.000021(X_3)$	0.063	0.312
$X_1 = 0.408 + 0.000026(X_3) + 0.0039(X_2)$	0.130	0.303
$X_1 = -0.523 + 0.273\ (\log X_3)$	0.078	0.309
$X_1 = -0.511 + 0.350\ (\log X_3) - 0.252 \log (X_2)$	0.172	0.295
$\log(X_1) = -1.116 + 0.261(\log X_3) + 0.196\ (\log X_2)$	0.189	0.211

Note:

Variables X_2 to X_8 are included in a stepwise regression analysis; only those significant at the 95% level are included in the equations.

All logariths are to the base 10.

Omitting X_1 therefore, the following equations were derived to estimate X_3, (mean FBM):

$$X_3 = 4548.28 + 53.616\ (X_7) \qquad R^2 = 0.076$$

$$X_3 = 3159.08 + 47.743\ (X_2) + 60.513(X_7) \qquad R^2 = 0.148$$

where:

X_3 = mean shipment size (FBM) on each retailer-manufacturer link greater than one trip per week

X_7 = GVW of retailer's largest truck

X_2 = Distance (unweighted) on each link

Available transportation capacity appears to be important in determining average FBM per trip, especially in combination with the distance covered. It seems that the general causal mechanism giving rise to different trip frequency intensities between individual pairs of manufacturers and retailers is: increasing distance and truck capacity encourage and enable higher shipment sizes, which in turn seem to be associated with slight increases in trip generation rates. The reason for this latter relationship is that for high frequency movements retailers attempt to maximize load factors. Once truck capacity limits are reached, the rate of increase in trip generation rates corresponds to the increase in quantity shipped. This is demonstrated by the high negative correlation (r = -0.608) between mean FBM per trip and the coefficient of variation of shipment sizes per linkage: as average shipment size increases on any one link the variability shipment size on that link decreases. This is probably due to the effect of truck capacity limits.

Retail Trip Attraction Rates

All retailers were then subjected to analysis on an individual site rather than linkage basis. The correlation matrix for the variables is shown in Table 10. An estimate of trips per day, allowing all independent variables to enter the equations if at the 95% significance level, produces:

$$X_1 = -0.39 + 0.328(X_4) \qquad R^2 = 0.68$$

$$X_1 = -0.62 + 0.308(X_4) + 0.0086(X_7) \qquad R^2 = 0.70$$

where:

X_1 = number of trips attracted to each retailer per week

X_4 = number of shippers (sawmills) supplying each retailer

X_7 = GVW largest retail truck

Trip attraction rates are overwhelmingly influenced by the number of suppliers the retail site uses, indicating the highly competitive nature of the manufacturer's local market and a tendency to "shop around" on the part of retailers. That truck capacity (X_7) should be the next most significant variable is not surprising, although the direction of the sign (positive) is hard to explain, especially since shipment size has a fairly strong positive correlation with GVW:

$$X_3 = 2170.6 + 92.37(X_7) \qquad R^2 = 0.243$$

TABLE 10

All Retail: Correlation Matrix

		(X_1)	(X_2)	(X_3)	(X_4)	(X_5)	(X_6)	(X_7)	(X_8)
Trips/day	(X_1)	1.00							
Weighted distance	(X_2)	-0.07	1.00						
Average shipment size to each retailer	(X_3)	0.26*	0.28*	1.00					
No. of suppliers	(X_4)	0.83*	-0.04	0.20	1.00				
% lumber in stock	(X_5)	0.32*	-0.08	0.17	0.33*	1.00			
% lumber retailed	(X_6)	-0.29*	0.11	-0.15	-0.33*	-0.58*	1.00		
GVW largest truck	(X_7)	0.41*	0.18	0.49*	0.34*	0.24*	-0.18	1.00	
Employees	(X_8)	0.40*	-0.06	0.13	0.43*	0.07	-0.12	0.33*	1.00

* Significant at 95% level.

It might be the positive sign is again due to the largest firms, and therefore the largest trip attractors, approaching truck capacity on those links which are heavily travelled. If the largest trucks normally have almost a full load, additional loads will cause an increase in trip attraction rates. If the smaller trucks (those of smaller firms, because r = 0.33) tend either not to have full loads, or be subject to frequent use relative to large trucks, the positive sign associated with trips per day might be less counterintuitive than it is. Perhaps the simplest explanation is that large firms have large trucks and also the highest trip attraction rates.

The confusion of interdependence amongst variables suggests that the matrix of partial correlation coefficients might expose the dominant relationships (Table 11). In Table 11, it can be seen that the number of suppliers is indeed strongly associated with the trip attraction rate, and that shipment size increases with distance (although there is only a weak relationship) and truck capacity. The percentage of retail stock which is lumber, and the percentage of lumber which is retailed, are also closely and inversely related. Neither variable, however, fits into the causative mechanism associated with trip attraction rates.

Site Ownership Distinctions

It is hypothesized that retailers which are part of a chain of operations (one firm owning several retail

TABLE 11

All Retail: Partial Correlation Matrix

		(X_1)	(X_2)	(X_3)	(X_4)	(X_5)	(X_6)	(X_7)	(X_8)
Trips/day	(X_1)	1.00							
Weighted distance	(X_2)	-0.13	1.00						
FBM	(X_3)	0.09	0.25*	1.00					
No. suppliers	(X_4)	0.74*	0.08	-0.07	1.00				
% lumber in stock	(X_5)	0.04	-0.06	0.05	0.08	1.00			
% lumber retailed	(X_6)	0.02	0.10	-0.05	-0.11	-0.51*	1.00		
GVW truck	(X_7)	0.20	0.12	0.39*	0.01	0.08	-0.01	1.00	
Employees	(X_8)	0.10	0.05	0.08	0.20	-0.10	-0.02	-0.05	1.00

* indicates significance at 95% level.

outlets) behave differently with respect to purchasing and transportation from those which are not, i.e. non-chain retailers. Significant differences can be observed between the means of the variables for each class of retailer (Table 12).

Chain retailers locate closer to their sources of supply, although this is deceptive because the sawmill industry is close to the center of the retail market in Greater Vancouver, so chain retailers probably locate closer to the center of their market, not the manufacturer's.

Mean shipment sizes are larger for chain retailers, due both to their larger average size (almost twice as many employees as the average non-chain retailer) and the fact that multiple deliveries probably take place: one trip from the manufacturer may serve two or more members of the chain.

However, the number of suppliers of chain retailers is smaller. It is known that chain retailers cultivate close relationships with a few mills to their mutual advantage: volume buying at discount prices.

Chain retailers concentrate more on non-lumber items than non-chain retailers, and retail rather than wholesale relatively more of their lumber stock. This results in smaller vehicle capacities being required, despite higher shipment sizes.

A regression analysis of sites' trip attraction rates, omitting chain retailers, indicates that the number

TABLE 12

Site-Ownership: Variable Means

Variables		Means		
		All Retail	Chain	Non-Chain
Trips/day	(X_1)	0.743	0.68	0.74
Weighted distance	(X_2)	11.88	10.74	12.19
Average shipment size to each retailer	(X_3)	5,384.37	5,733.05	5,204.90
Number of suppliers	(X_4)	3.40	3.33	3.41
% lumber in retail stock	(X_5)	71.79	66.30	73.02
% lumber retailed	(X_6)	52.17	64.57	49.55
GVW largest truck	(X_7)	34,792	32,300	35,224
Employees	(X_8)	9.54	14.22	8.04

suppliers of lumber is again most significant in determining trips:

$$X_1 = -0.45 + 0.345\ (X_4) \qquad r^2 = 0.69$$

Non-chain retailers' trip attraction rates are slightly more sensitive to changes in the number of suppliers than is the trip attraction rate for all sites.

If we allow other variables to be added to the equation, we obtain:

$$X_1 = -0.59 + 0.305\ (X_4) + 0.035\ (X_8) \quad r^2 = 0.71$$

and

$$X_1 \quad -0.85 + 0.300(X_4) + 0.033(X_8) + 0.008(X_7)$$
$$r^2 = 0.73$$

That employment size should enter the equation is an encouraging sign of the validity of making the group of sites more homogenous with respect to ownership.

The number of suppliers to sites is only significant for a specified industrial-marketing-retailing structure. It has no validity should that structure undergo a major parametric change, such as the complete ownership intergration of manufacturing and retailing. In such a case, where a manufacturer might have a monopoly on the retailer's stock, the number of suppliers could be reduced to one, yet the number of trips, because of the limits imposed by truck capacity and inventory economics, would not fall below a threshold not currently predicted by our model. In other words, the equation structure developed presupposes a competitive supply structure for the retailer. Under other than competitive (non-oligopolistic or non-monopolistic) conditions, the importance of employment size and truck capacity might be expected to take on renewed significance.

This chapter has estimated the volume of truck trips attracted to retail sites as a function of characteristics of the retailer, the commodity supply market, and truck capacity and ownership. The number of mills supplying a retailer is closely associated with the number of trips arriving at the retail site over any time period. This is intuitively obvious only if we take into account the diverse and competitive structure of the wood products industry. It does not necessarily hold for other industries.

Trip attraction rates tend to be inversely related to distance from source of lumber supply, although the relationship is insignificant. This conforms to the previous expectation that distance does not strongly affect truck trip generation rates in urban areas. The only significant affect of distance is to increase shipment size.

The size of the activity site, in terms of number of employees, is much less important in estimating transport demand for retailers than is the case for sawmills, but marketing and transport supply variables appear to be more significant. Partial correlation analysis exposes the most basic associations between variables: the number of suppliers to each retailer and truck capacity are positively related to retail trip attraction rates.

Finally, retailers may be distinguished on the basis of their ownership; a retail site may be either an individual financial unit, or part of a commonly owned chain of retailers. The tendency appears to be for chain retailers to take larger shipments and use less sources of lumber supply, which in turn causes lower trip attraction rates.

CHAPTER IX

FORECASTING THE VOLUME AND SPATIAL INCIDENCE OF URBAN TRUCK MOVEMENTS

The purpose of testing models which improve our knowledge of the factors underlying the demand for urban truck movements is to contribute towards the methodology of modelling and forecasting urban truck trips. As pointed out in Chapter II, commercial vehicle movements are an important and frequently overlooked component of the urban transport problem. Subsequent marketing model tests indicated that estimates of trip demand, using data for a cross-section in time, can be improved and explained by taking into account the physical distribution channel behaviour of firms. This chapter sets out the conditions under which the marketing model will or will not hold when the model developed on cross-section data is used to forecast future trip generation and attraction rates.

It is always tempting to use the results of multivariate analysis to estimate future events. Unfortunately, cross-section analysis is but a snap-shot in time; we have no assurance that the conditions in which that snapshot occured will hold. In fact they probably will not, since the set of equations on which forecasts are to be based are probably but part of a larger, more complex, system. At least in the social sciences, we can rarely be sure that there are not phenomena exogenous to a model which are nevertheless related to it, and whose importance will only be realized with the passage of time. We should therefore isolate the conditions under which our models will hold, and attempt to suggest what effects changes in those conditions will have. The further into the future extrapolations are made, the more they become independent of historical data. Structural changes, such as those in technology, tastes, values, and politics become increasingly significant.

There are two types of change affecting truck trip generation rates which concern this chapter: those which <u>necessarily</u> pose limitations on the model, and those which do not. The latter include:

(1) A change in the volume of local shipments.

(2) A change in the local marketing channels of manufacturers.

(3) Changes in the classification of individual channel participants.

(4) Application to other urban areas.

(5) Application to other commodities.

Changes through time which <u>would limit the model</u>, or at least affect its coefficients in an identifiable way, include:

(1) A shift in the productivity of firms

(2) A change in product characteristics, especially weight per volume, or handling requirements.

(3) A change in transportation ownership identities

(4) A choice of transport mode

(5) A change in the competitive structure of either manufacturing industries or marketing channel participants

Future Conditions Which Do Not Limit the Model

(1) Changes in output indicators for economic activity systems: Possibly the most important changes in the environment surrounding the cross-section marketing model relate to shifts in the relationship between and magnitude of the output indicators which are associated with transport demand. The demand for a commodity at the point of production may be indicated by orders, production, employment, or shipments. Two aspects of these indicators' time series are important:

- their individual variation through time;
- their interrelationship between leads or lags.

The temporal variation of economic series is traditionally described in terms of trend, cycle, and random fluctuations. In an examination of the series for the B.C. coastal sawmilling industry (Figure 23), we can observe an almost 100% increase in production during 1959-1972. Within this trend, however, two distinct cyclical components are evident: (a) that related to the general business cycle, so that there was a decline in production during 1968-1970, followed by renewed and accelerated growth, and (b) a seasonal

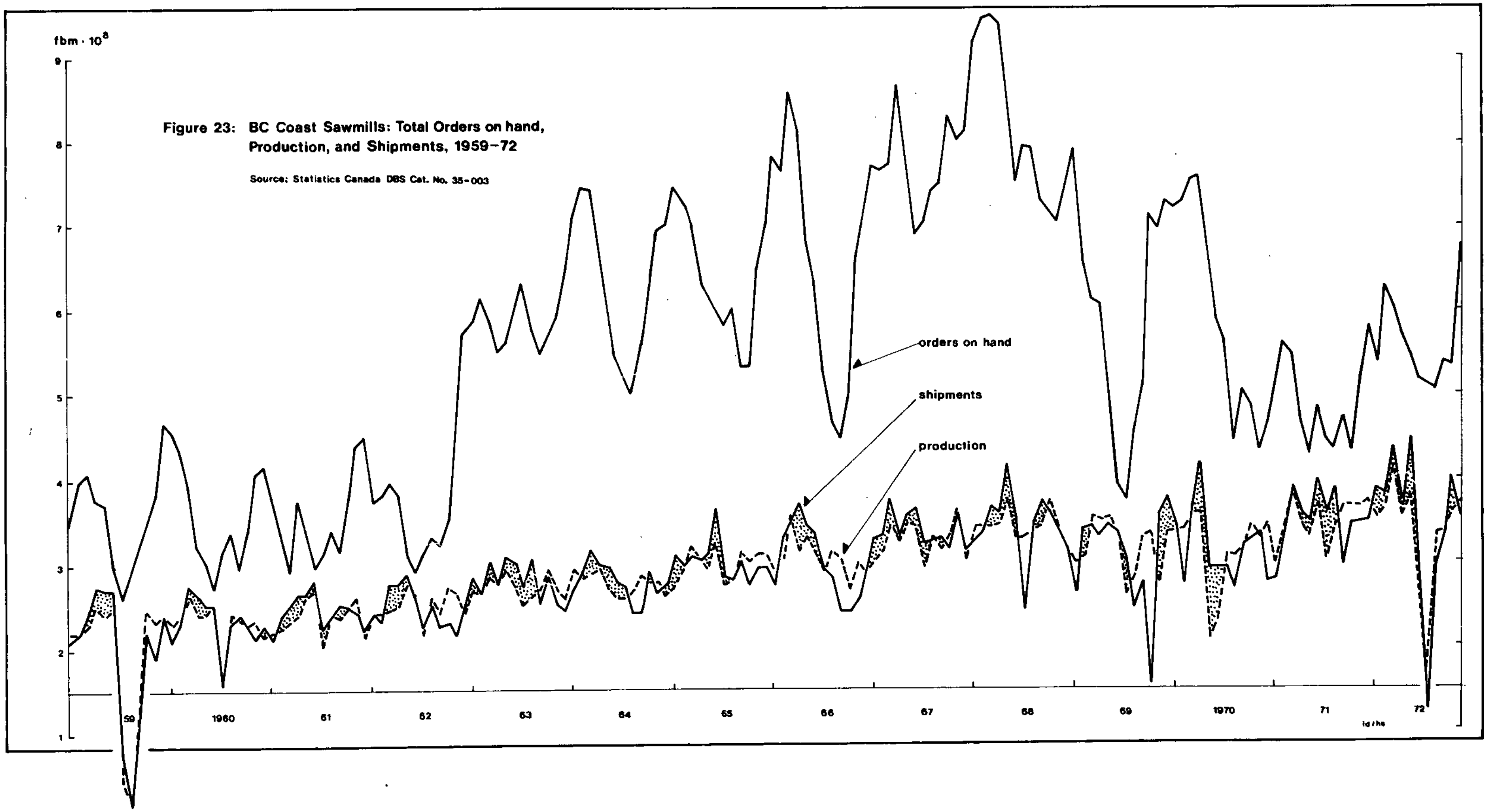


Figure 23: BC Coast Sawmills: Total Orders on hand, Production, and Shipments, 1959–72

Source: Statistics Canada DBS Cat. No. 35-003 cycle characterised by spring and early summer highs and winter lows, mainly as a result of dependence on construction activity and partially because of winter log supply difficulties. The most obvious random factor is effect of strikes, either in the production or transportation industries, which cause sudden drops in production, shipments, or both, and surges of volume shipped before the strike period (in its anticipation) or after (to compensate pent-up demand).[1]

The implications of this series for trip generation forecasts are clear: models based on total employment will show a steady increase in the number of trips from manufacturing sites, subject to the perturbations noted above. The time series for local shipments (Figure 24), however shows very little trend or non-seasonal cyclical effects. Unless total employment is adjusted by estimates of local (non-basic) employment, therefore, local truck trips generated could be seriously over-predicted. The other aspect of the series for local shipments which is informative is the nature of the seasonal cycle (Figure 25). Two persistent highs exist: early summer and fall. Average months are February-March and September-October, and surveys of lumber movements should therefore be undertaken in these months, because they are representative of the whole year, and also they exhibit less

---

[1]There is good reason to doubt that this is in fact random, since major work stoppages occur during the summer and/or in periods of either business recession or price inflation.

Figure 24: BC Coast Sawmills:
Local Orders on hand and Local Shipments, 1959-72

Source: Statistics Canada DBS Cat.No. 35-003

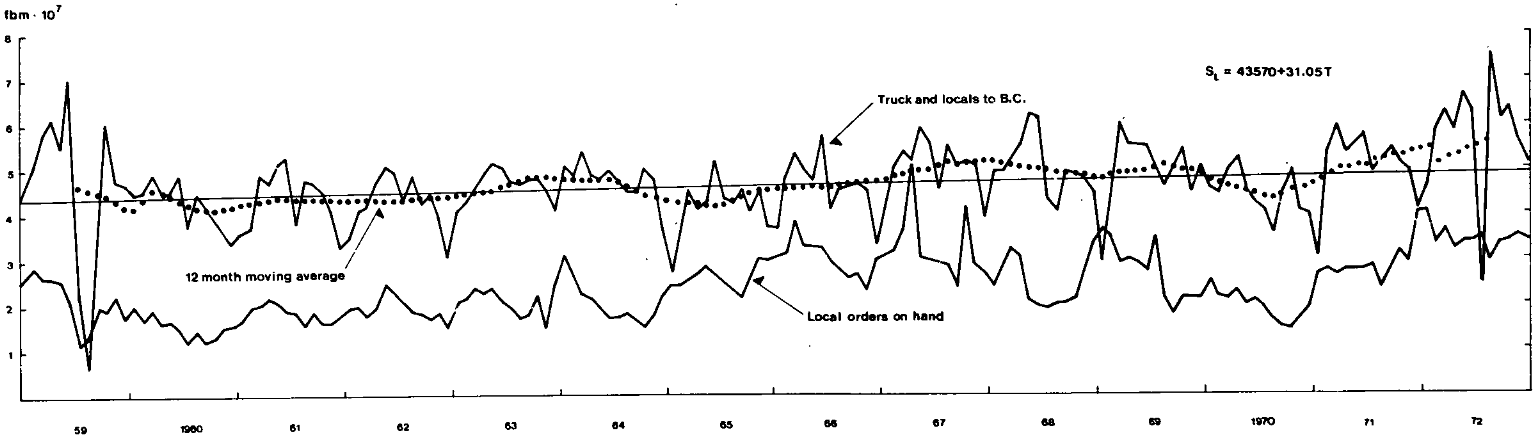
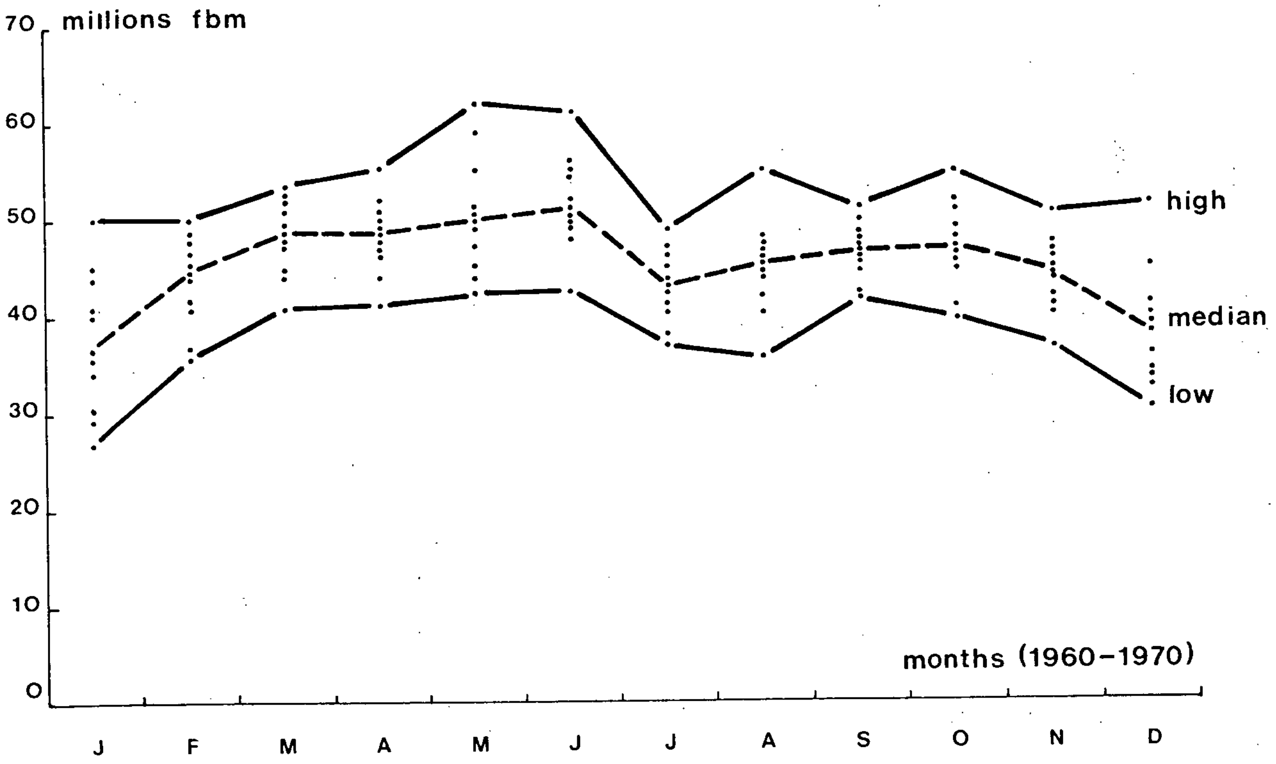


Figure 25: British Columbia Coast Sawmills: Truck and Local Shipments By Month (1960-1970)



source: DBS Cat. No. 35-003

id/hs

fluctuations in volume shipped (1960-1970) than most other months.

There is a substantial body of literature on the demand for wood products, most of it either with reference to cyclical variation and the relationship with business and construction cycles, or to the price and cross-elasticities of demand for lumber. Two dated but still relevant studies of cyclical relationships suggest hypotheses which might be considered in forecasting lumber demand.[2] Zivnuska, in a study of the period 1904-1948, found that 55% of lumber was consumed in activities which vary closely with the business cycle. This percentage is increasing, and we may expect the general business cycle to become more important in estimating future demand and its timing. Furthermore, and this is supported by White, the amplitude of cyclical fluctuations is tending to decrease due to government anti-inflation policies.[3] Thus we may rely on expected average growth rates, with decreasing concern for the effect of cyclical developments, in forecasting the level of demand.

The above remarks are appropriate for estimating aggregate, national demand. In the case of particular urban

---

[2]Zivnuska, J. A. Business Cycles and Commercial Forestry. (New York: Institute of Public Administration, 1952).

Mead, W. J. "Changing Pattern of Cycles in Lumber Production", Journal of Forestry, (November, 1961), 808-13.

[3]White, D. A. Business Cycles in Canada. (Ottawa: Economic Council, Staff Study 17, 1967).

areas, the micro-effects of residential construction, population growth, and factors affecting the elasticity of demand become important.[4] In particular, Thompson raises the question of there being a distinct local cycle which is not just a reflection of the national cycle. If an area's economy is dominated by cyclically unstable industries, more violent fluctuations in economic (including transportation) activity might be expected than elsewhere. The demand for durable goods (lumber) is more unstable than for non-durables (paper). The demand for producer goods (lumber and plywood) is more unstable than that for consumer goods (houses and furniture). All elements are important in the Greater Vancouver economy, so it is difficult to draw conclusions about their relative significance. Such distinctions might, however, suggest that different set of leading indicators should be used in cities with economic bases different from Vancouver's. Furthermore, increases in city size are normally accompanied by increases in industrial diversification, which in turn might be expected to cause a trend toward urban cyclical stability since seasonal patterns of demand tend to differ amongst commodity groups and different industries' growth trends are infrequently coincident over time.

---

[4] Alberts, W. "Business Cycles, Residential Construction and the Mortgage Market", Journal of Political Economy, 70 (1962), 263-281.

Campbell, B. E. Population Change and Building Cycles. (Urbana, Ill: University of Illinois, Bureau of Business and Economic Research, 1966).

Thompson, W. R. A Preface to Urban Economics. (Baltimore: Johns Hopkins Press, 1965, p. 139).

When the elasticity of demand for a commodity is high, knowledge of its behaviour and magnitude are almost as important as industrial growth and cyclical factors in estimating future transportation demand resulting from commodity demand. Three sources of elastic demand are significant:

(a) Price, or sometimes anticipated price, of the commodity.

(b) Substitutability with other products (cross-elasticity).

(c) The elasticity of demand for subsequent products.

In a survey of estimates of the price elasticity of demand for lumber, Rich found that values varied from 0.2 to 0.63, with 0.25 being the most likely.[5] The payoffs from attempting to measure the elasticity of demand for different commodities and integrating these into a comprehensive model of urban goods movement are probably quite low relative to the costs of doing so, especially for commodities such as lumber where demand is inelastic in the short run. It is probably useful though to be aware of general trends towards the substitution of products by the re-manufacturing and consuming sectors of the economy before making assumptions about the growth of commodity production.

---

[5]Rich, S. U. Marketing of Forest Products: Tests and Cases. (New York: McGraw Hill, 1970), p. 33.
See also: Reed, F.L.C., "Elasticity of Demand for Wood Products", Paper presented at the Annual Conference of Western Forest Economists, Wemme, Oregon, (April 21st, 1966).

Not only the nature of growth in, but also the relationship between output indicators is a change which would not necessarily invalidate the model. An output indicator may be orders on hand, production, or shipments. The marketing model of truck trips proposed in this study hypothesized that trips are a function of local employment and marketing channels. This is partly based on the reasonable assumption that production and employment are closely related by a function which does not lag through time. However the model is also based on the more questionable assumption that trips (shipments) and employees (production) are similarly directly related: i.e., that the same quantity is shipped as produced in the survey time period. Carlson found that the production period for lumber, based on two different sets of U.S. data, varied between two and three weeks.[6] An alternative but crude test of the nature of leads and lags in the order - production - shipment cycle is to regress appropriate monthly time series and select the best fit as the relationship which gives the magnitude of the lead or lag to the nearest month.

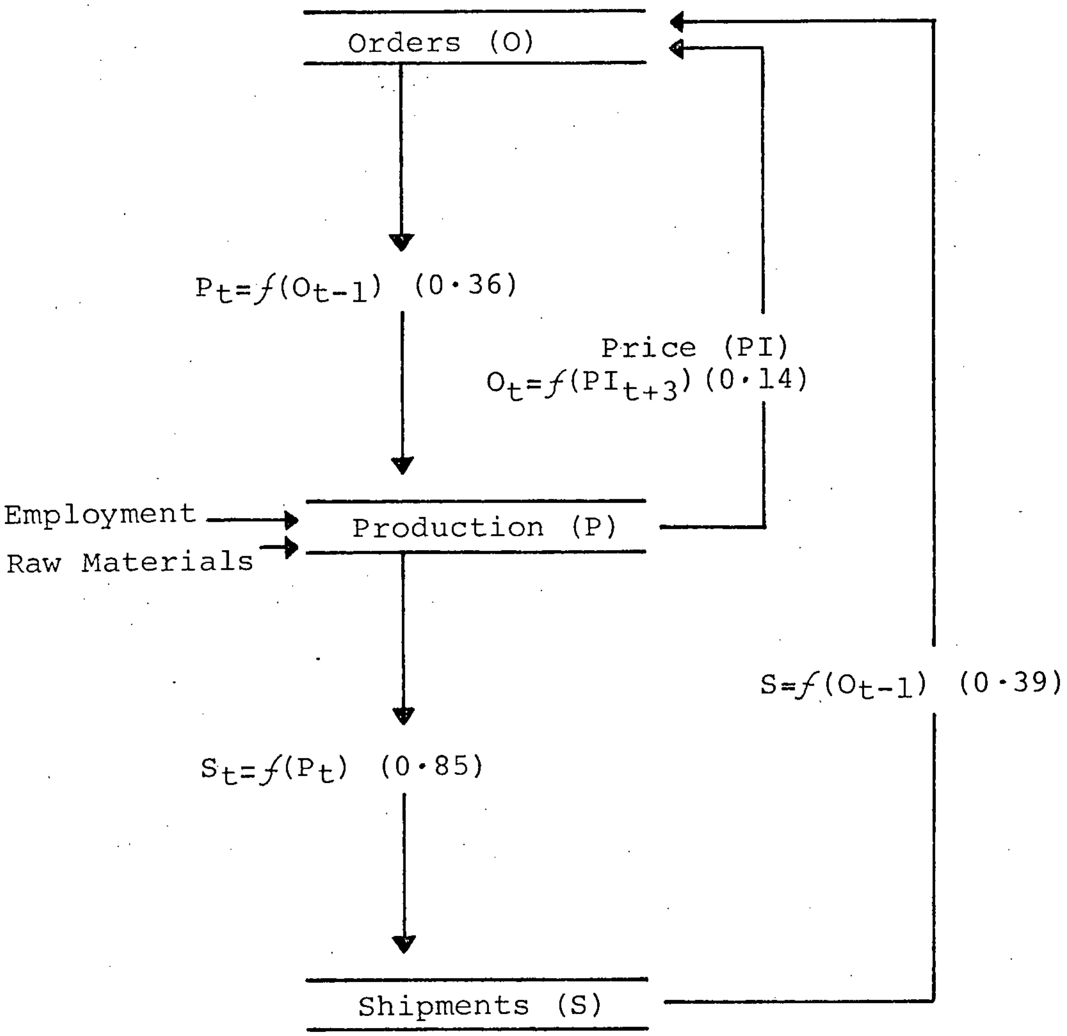
Figure 26 (1959-1965) shows the cycle for total coastal B. C. production and shipments. As expected production and shipments vary closely, shipments and production

---

[6] Carlson, J. A. "The Production Lag", The American Economic Review, 63, 1 (March, 1973), p. 78.

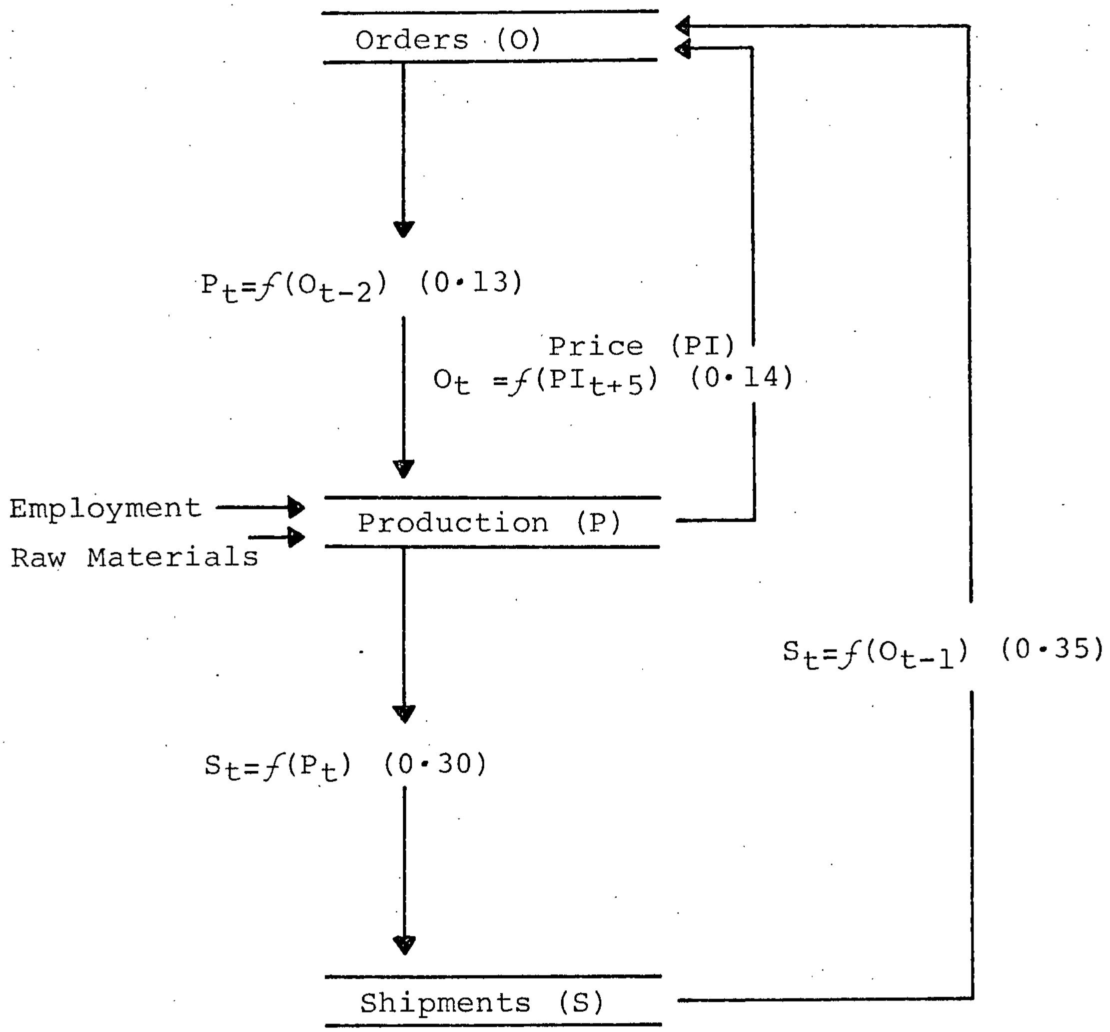
"Production period": time between beginning of production and completion of finished product.

Figure 26a: Total Order - Shipment Cycle (1959-65)
(Leading and Lagging Relationships)



Key:
$Y = f(X)$ (R)
$\equiv Y = a + b(X)$ (r^2)
$t-1 \equiv t-$(one month)

Figure 26b: Total Order - Shipment Cycle (1966-70)
(Leading and Lagging Relationships)



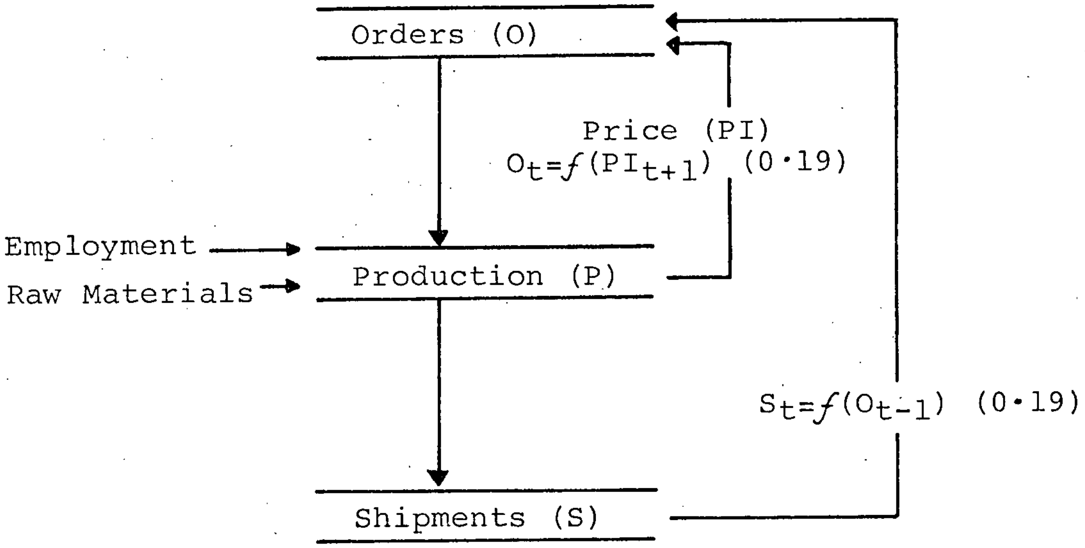
Key:
$Y=f(X)$ (R)
$\equiv Y=a+b(X)$ (r^2)
$t-1 \equiv t-$(one month)

both lagging orders by t-1 (one month), but with a poorer cooreIation than shipments and production. It is also suggested that orders are partly based on anticipated prices, on the theory that orders are high at time t in the expectation that prices will be higher (than present) at t+3. In the period 1966-1970, a time of greater instability in the B.C. lumber industry, production and shipments still correlate best without a lag.

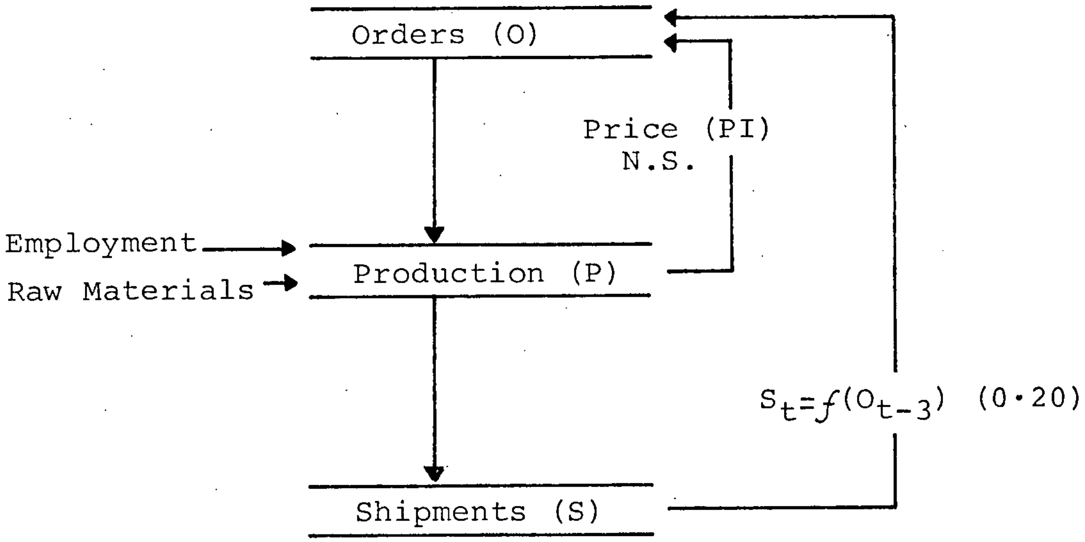
The same data can be used to give only vague insights into the local market (Figure 27). There is much less concern here with anticipated price, presumably because of the costs of stocking up in advance of price increases. Shipments still lag orders but only through weak relationships; in fact lags of t-1, t-2, and t-3 could almost equally well have been presented in both time periods, which indicates that the local market is substantially less volatile than that for exports. There is no reason to suppose that production and shipments do not vary closely together in the manner suggested by Carlson, although no data are available to test how distorted would be the estimation of shipments from employment (production) if the survey period for both variables was a week or less. Future knowledge of the levels of inventory in local marketing systems might show to what extent they are used a hedge against uncertainties or a reservoir against time lags in procurement.

The changes in output indicators affecting truck trip generation rates have been discussed at length, partly

Figure 27; Local Order - Shipment Cycle (1959-65)
(Leading and Lagging Relationships)



Local Order - Ship-ent Cycle (1966-70)
(Leading and Lagging Relationships)



because this enabled a test of one of the factors on which the marketing model was based. The next four possible future conditions which do not necessarily invalidate the model can be covered briefly.

(2) Changes in Manufacturers' Local Marketing Channels: If a manufacturer changes his local distribution channel, from remanufacturer to retailer for example, the model should adjust trips generated upward accordingly. Note that this contention holds constant the competitive structure of the industry and/or market constant. In other words, if the retailer to whom the manufacturer ships is not indepedent of that manufacturer, trips may be lower than expected. A possible change in marketing channel is that manufacturers might increasingly by-pass middlemen and ship direct to the point of end-use (the construction site for example) either through office wholesalers or their own sales office. Some of this activity takes place now, but it is not significant enough in the lumber market to warrant the inclusion of this channel in the trip estimation model. If such trips were to increase, this channel could be added to the equation in the same way that retailers were. However, the extreme variability of shipment sizes and the dependence on actual construction activity would reduce the predictive power of this or any other model.

(3) The Classification of Channel Participants: In the local market it is distinctly possible that the embodyment

of the wholesaling function in separate institutions might disappear. Wholesalers, as we have seen, create time and place utility in the spatial economy; the overhead charged for this service could become prohibitive both to manufacturers and down-channel participants. Instead, manufacturers and retailers could increasingly take over wholesaling functions, the former selling through their own sales outlets, the latter buying in greater bulk and providing their own assortment purchasing personnel and capacity. It is not clear that the wholesaler is disappearing, despite the trend towards manufacturers sales branches and chain retailing.[7] If the wholesaling function does shift among channel participants, re-classification of institutions should correct for this in trip estimation equations. However, if the shift is onto the manufacturer, which we may regard as a change in competitive structure since both production and marketing would be controlled by one firm, a further limitation could be placed on the model.

(4) Application to Other Urban Areas: An urban transportation model whose applicability is restricted to one set of phenemona or one place is of limited utility and its validity is suspect even in the environment for which it was developed. Application of the marketing model, incorporating local

---

[7] Ronalds, K. L. "A Study of the Distribution System in the British Columbia Building Materials Industry", University of British Columbia, MBA Thesis, April 1968.

employment and marketing channels, to other urban areas would not per se limit the model's use. It can be added that the model which includes specific marketing variables rather than general variables such as total plant employment makes adjustment for application to other urban centres possible.

(5) Application to Other Commodities: The same might be said of the model's applicability to other commodity groups. Once we know the proportion of production exported from area manufacturers, the structure of the local distribution channel network, the probability distribution of shipment sizes, and the labour requirements per unit of commodity, accurate and adjustable models of trip generation rates of all manufacturers are possible. "Adjustable" is stressed because the great advantage of the model-type developed is that dynamic changes in the industry and the rest of the economy can be incorporated, which is not true of simple models based on total employment or floor space.

Future Conditions Which May Limit the Marketing Model

The following factors are of the type which may invalidate the model in its present form. That is to say that the model would not withstand changes in these factors without biassing the predicted trip generation rates. If the nature of the bias is known or can be estimated, however, it is quite conceivable that the structure of the predictive equations could be manually adjusted to incorporate their effects.

(1) <u>A Shift in Productivity</u>: Two aspects of output per employee are important. First, there is the question of the consistency of the relationship between employment and production in the short run, technology being held constant. White has suggested that the elasticity of employment reductions is generally greater for contractions in output than for expansions.[8] Knowledge of the lead between employment and production, as well as the elasticity of demand for labour with respect to output would add clarity to the probability of error in survey methods in much the same way as did the examination of production-shipment relations.

Secondly, and more significant for model applications, longer run changes in technology cause changes in the relationship between employment and output. The lumber industry has undergone relatively minor technological innovation during past years, and,while the output of the industry continues to be lumber rather than finished or semi-finished products, this condition should continue. We could hypothesize that the reason for a low rate of innovation might be that in more purely competitive industries (many small firms) the rapid dissemination of new technology retards the tendency to innovate because advantages to the innovator are quickly lost. On the side of production it is unlikely that the impact of new machines on the productivity of employees could

---

[8] White, D. A., op. cit., p. 199.
"Elasticity of employment reduction (or expansion)": % Δemployment/ % Δin production.

not be accounted for in the model.

Changes in the productivity of distribution channels are not only more probable, but are less easy to incorporate into the model structure. Change may occur with respect to the labour efficiency or intensiveness of either marketing (retail and wholesale) agencies of transportation firms and functions. The former was covered under the subject of retail trip attraction rates, and effects of changes in retailing efficiency can be detected if a trip attraction survey complements a manufacturing trip generation study. The impact of changing truck capacity, which may result less from technological innovation than from fleet conversion to large-capacity units, would be hardest to assess. Knowledge of not only the extent and rate of change is required, but also of load factors on vehicles, and both these require quite intensive surveys. On the other hand, radical or rapid departures from current transportation capacity are unlikely in the lumber industry and many others.

Another change which could be important is that of "non-productive" employment in manufacturing or marketing, by which is meant employment in managerial, purchasing, advertising, office and sales tasks. Much of the increased efficiency by these employees should be reflected in increased volume at the production and shipment (materials - handling) levels. Some of it may not, however, since more effective integration of transportation could result in reduced trips for the same quantity shipped.

(2) <u>Changes in Product Characteristics:</u> In Chapter III we saw the conditions laid down by Hoel for the weight or volume capacity of the truck determining quantities which can be shipped. If the critical commodity density, truck weight capacity/volume capacity, is less than the shipment's density, then the weight capacity of the truck will determine the amount of the commodity which may make up a truck load. If the critical commodity density is greater than the shipment's density, then the truck's volume capacity is the determining factor. A change in transport technology, or, as is more probable, a fleet-conversion on the part of the user (from flat bed to van, for example) could cause changes in the value of the truck-load limit.

A change in the shipment's density, rather than the critical commodity density, is equally if not more likely. Changes due to packaging are common, pre-packaging for resale at the manufacturing plant instead of elsewhere in the distribution channel for example. In this case, additional manufacturing employment for the packaging process might sufficiently estimate the increase in trips. However, if the process is automated, and packaging comprises a substantial part of the final product's volume, the increase in trips may be underestimated.

Apart from density, the fragility or perishability of a product influences the demand for transport. Fragile products may not tolerate bulk handling. Products which may not be stacked in a truck generate more trips per unit weight or volume than those which can. Perishable commodities may require rapid shipment between points of production and consumption owing to their high costs of storage. Packaging or other storage improvements may reduce the demand for transport, although resulting significant changes in product density may offset their effect on vehicle trips.

(3) <u>Changes in Transport Ownership Identities:</u> Centralized control of trips emanating from a manufacturing site should result in the optimization (cost-reduction) of the number and distribution of trips. This was hypothesized in Chapter IV. The manufacturer is faced with three non-discreet choices in selecting his truck transport supply. These are, with their general effects on trip generation rates:

(a) Manufacturer's PMT, due to which we might expect maximum reduction of trips.

(b) When a manufacturer uses a for-hire carrier, a lesser reduction of trips is likely, since the carrier attempts to optimize flows over <u>his</u> whole network, not just the manufacturer's in question. Transportation divided amongst several for-hire carriers, perhaps according to market distribution, would not necessarily cause further increases in trips. For-hire carriers operate on the principal of integrating many LTL shipments into a pick up and delivery network, and trip generation rates may well be indifferent as to whether the manufacturer's LTL shipments form part of one carrier's network or several.

(c) Customer PMT: an extension of the for-hire carrier case, the difference being that only one LTL shipment is picked up, whereas the carrier, and of course manufacturer's PMT, may take more than one. Trip generation rates should be correspondingly higher.

The marketing model of trip generation could be invalidated if, over time, a change from one type of transport supply to another takes place. This is not to say that the effects of such changes could not be modelled in the future. This argument for expected differences in trip generation rates based on transport ownership applies to other, non-manufacturing, distribution channel institutions. The effective of ownership on trip attraction rates can also be deduced.

(4) Changes in Mode of Transport: There is no reason to expect a shift away from trucks as the overwhelming mode of urban goods transport. On the other hand, for some types of movement alternative modes are feasible and might be increasingly used in the future. The case of barges being used for bulk shipment to export terminals has already been mentioned. Less obvious substitutes are pipeline and rail. For purely intra-urban shipments, the use of pipelines is at present restricted to a few (non-Canadian) pneumatic tube systems for mail delivery and the transfer of liquid or gaseous commodities between manufacturing plants. An example of the latter in the Vancouver wood products industry is the

pipeline shipment of plywood manufacturing by-products to an adjacent and subsidiary chemical plant. In the future, more widespread re-cycling as part of continuous production process may see more frequent use of urban pipelines, although such a case would not cause a total reduction in truck trips, merely an introduction of new sets of flows with a new mode of transport.

The incidence and magnitude of rail transport, while important for urban transport capacity, and its impact on the urban fabric, is a function of the inter-city and non-urban distribution network. Possible changes may be brought about by the use of rail transit systems for intra-urban goods movement in hours outside periods of peak passenger demand.

(5) The Competitive Structure of Manufacturing and Marketing: Changes in industrial structure can also lead to the invalidation of a model calibrated on cross-section data. An acceptable working definition of market structure might be:

> "those permanent, or slowly changing, competitive limitations of which a firm must take account in formulating its own policies. The most important of these limitations are the number and size distribution of buyers and sellers in the market, the conditions of entry of new firms, and the extent of product differentiation, including geographical dispersion."[9]

---

[9] Mason, E. S., "Preface", Antitrust Policy, C. Kayson and D. F. Turner (Cambridge: Harvard University Press, 1959).

The market structure of the lumber industry in, and producing for, Greater Vancouver can be characterized as many firms with a wide ranging size distribution and large market of mainly small retailers, wholesalers, and remanufacturers; increasing barriers to entry, in part due to the control of log supply by larger companies; and a low level of product differentiation. To Mason's market structure determinants we might also add the type and degree of vertical integration: in the local lumber industry the trend is towards integration of the manufacturing and wholesaling sectors.

The implications of some changes in market structure have been described previously, especially those relating to the size of individual firms and product differentiation. Another aspect is the competitive nature of industrial structure. One hypothesis may be that as competition in an industry declines, the transportation demands of individual firms stabilize. The effect of a decline in the degree of competition between manufacturing firms is that a shift in either product price or physical characteristics will not significantly change their market shares. This condition may be brought about artificially through collusion: tacit agreements not to attempt significant changes in market share through pricing competition may develop.

Two broad classes of indicators of competition might usefully be monitored and forecasted in programmes for planning urban goods movement: structure of the market and behaviour of its participants.[10] Market structure, in addition to the factors noted in the previous definition, can also be described by barriers to the entry of new firms, which, if sufficient, give rise to oligopolies. Bain has cited inumerable barriers to entry, although the product differentiation advantages of established firms and economies of large-scale production and distribution are the two most pervasive types.[11] The behaviour of participants in the market may be described in terms of collusion among competitors regarding price or volume of output, exclusive contracts, or price discrimination. An indication of collusion may be the "high rigidity of formal structure over time".[12]

A high incidence of these behavioural measures may signify an oligopoly, such as exists in the pulp and paper industry and perhaps even in the lumber export market. Oligopolies are successful when firms in the market are few, costs are similar, barriers to entry by other firms can be

---

[10] Massel, M. S., Indicators of Competition. (Washington: The Brookings Institution, 1962), Ch. 7.

[11] Bain, J. S., Bariers to New Competition. (Cambridge: Harvard University Press, 1956).

[12] Shepherd, W. G. Market Power and Economic Welfare. (New York: Random House, 1970).

erected, and customers are many and small, or not fully intent on minimizing the price they pay for the oligopolist's product. What are the consequences of a trend towards oligopoly in an industry for local transport demand? For one thing, the rigid price structure probably holds in a market decline, the full impact of a recession being borne by a reduction in production and employment. Thus the transportation demands of oligopolistic firms may be predicted better by the expected magnitude and incidence of general business cycles than is the case in more competitive industries. Furthermore the oligopolist tends to produce a more diverse line of commodities, especially if it is a large firm, because the constraint of non-price competition encourages an emphasis on product differentiation and it can bear the costs and risks of research and development more easily. The diversity of products may lead to a more complex delivery network, though not necessarily higher trip generation rates unless the product is basically static and the diversity arises only from packaging and other unitization changes.

One can argue that countervailing power will give rise to oligopsonies: a few, large buyers of the manufactured good. The powerful buyer may either, at the two extremes, undertake vertical backward integration and optimize his transport supply in the total manufacturing-distribution-retailing system he owns thus reducing transport demand to a minimum, or he may use his power to extract the maximum level of service, perhaps exemplified by frequent LTL shipments, out of his suppliers.[13] Large urban retailers of both food and dry goods provide examples of both types, but they have increasingly shifted toward the former as their market power has increased.

This overview of possible changes in the environment within which transport demand operates has indicated the dangers in applying a cross-section model to forecasting problems. The two future conditions which it seems may pose the greatest problems for truck movement forecasting are:

(a) A significant change in the lag between commodity output indicators (employment, production) and transport demand indicators (shipments). Aggregate statistics may be used to estimate such lags and thus build into the model appropriate adjustments.

(b) A significant change in the institutional structure of economic activity, and therefore in the behaviour of firms, may well cause changes in transport demand. This cannot readily be accounted for within the current model's framework; suspected changes in firm behaviour will necessitate re-calibration of cross-section models either by conducting new surveys or using survey results from other cities.

---

[13]Baligh, H. H. and L. E. Richartz, Vertical Market Structures. (Boston: Allyn and Bacon, 1967).

CHAPTER X

CONCLUSIONS

New insights into the movement of commercial vehicles can be gained using an empirical-behavioural approach. The following general conclusions emerge from the study of the Vancouver wood products industry:

(1) An understanding of goods movement is an essential prerequisite to that of commercial vehicle movement.

(2) There are deficiencies (variable - selection procedures, level of aggregation, etc.) in current transportation models.

(3) There is no need to extend the impact of these deficiencies by transferring passenger transportation demand models and methodologies to truck movement demand without modification. In particular, we should ensure that our models hold for micro-systems of activity before applying them to whole urban areas.

(4) Transport supply, especially the ownership characteristics (PMT, common carrier) of that supply, has a real impact on trip generation rates. In the Vancouver Sawmills case study, the fact that retailers of lumber provide their own transport caused a significant increase in

trip generation rates at sawmills with a high volume of local shipments being marketed directly to the retail level.

(5) Industrial linkage research may be expected to provide more theoretical and empirical information for future commercial vehicle movement studies.

(6) Various aspects of industrial structure and physical distribution should be an integral part of urban good movement analyses and forecasts; especially the size distribution of firm and other indicators of competitive structure, the role of power and risk in marketing channels, and the mechanisms for balancing ordering and carrying costs.

(7) Product characteristics, weight/volume relationships, physical attributes, and their peculiar transport requirements, should be quantified.

(8) The survey data required for adequate truck movement studies are well within the survey capabilities of most planning agencies.

(9) For more complex urban regions than Vancouver, especially megalopoli, truck usage should be expressed as a probability at a distance. For forecasting purposes, intermodal price and service competition should be taken into account. In the Vancouver wood products industry case study, modal split was not a problem. Within a certain market area, virtually all shipments move by truck; beyond that area other modes are used, the only major complication being shipments by truck to dock.

(10) Several sources of data error in the revised (marketing) model are significant for its application, but they can be measured and corrected. The main ones are variations in modal split between firms, measures of employment, non-product (waste) vehicle movements, and the time period over which trips are surveyed or within which the cross-section data are collected.

(11) Waste movements are a special case, they can be ignored without unduly disturbing the effectiveness of goods movement estimation procedures, but this could eliminate a substantial number of actual vehicle movements. Also data on waste movement are in increasing demand for re-cycling and environmental quality studies, so it should ideally be collected but analysed under a different set of assumptions from commercial products. Waste is, after all, normally subject to disposal, not marketing.

(12) The addition of marketing variables (for example the percentage of product to retail rather than re-manufacturing sites) improves standard trip generation functions, but also, and more significantly, places such functions in their total economic activity system perspective.

(13) Data on trip attractions may be collected along with those on generation by identifying truck destinations from other economic activity sites. Not only does this provide data for the trip distribution stage of transportation analysis, but it complements trip generation data

in describing truck movement activity at individual sites.

(14) Trip attraction rates at the retail site may be at least as much a function of firm behaviour as firm size. In the Vancouver case, the variation in wood products retailers' trip attraction rates was explained by the number of suppliers and truck capacity for each retail site than number of employees.

(15) The availability of aggregate industrial and marketing data allows micro and macro assumptions and findings to be compared. For example, in this study, the assumption of insignificant lags between local employment, producing and shipping was supported by the analysis aggregate industry statistics.

(16) Cross-section survey data and research findings should be put in their total temporal perspective. Time series of the variables should be examined in order to observe trends and long-run cycles, which may be useful for forecasting, and seasonal or weekly variation, which help to indicate when surveys should be conducted and biasses in survey results. The study of local truck movement in the Vancouver sawmill industry argued that surveys of individual vehicle movements from a plant should be conducted over a period of one month, and that certain months of the year were much closer to the annual average than others. A survey of the summer months alone which is common in urban transport data collection, would have provided biassed results. Summers tend to be

characterized by employee vacations, labour disputes, and slow local demand.

(17) Lastly, the future conditions under which the model of urban truck movement will or will not be applicable should be elaborated in all further studies. This is a contention and guideline which is too rarely observed in most urban transport research. Certainly in the wood products industry case study, changes in transport demand would go unexplained without insight into the behaviour of firms and the competition structure of the industry.

Commodity and commercial vehicle movements in urban areas have received increased attention in recent years because of their importance to urban economic efficiency and the quality of city life. There is no doubt that our resources and energies are wasted on piecemeal studies and unrelated problem solutions. This study has attempted to place urban truck movements in a complete behavioural, and to some extent spatial, perspective. It is to be hoped that the approach and major findings will not only create a new awareness of the factors influencing the demand for urban truck transport, but will also lead to the development of comprehensive models of urban transport activity and thereby to more informed and integrated urban policy and planning.

BIBLIOGRAPHY

METHODOLOGY, URBAN PLANNING, AND URBAN TRANSPORTATION

Berry, B. J. L. and F. E. Horton (eds.) Geographic Perspectives on Urban Systems. Englewood Cliffs, N. J.: Prentice Hall, 1970.

Bourne, L.S. Internal Structure of the City. London: Oxford University Press, 1971.

Boyce, D.E., N. D. Day, and C. McDonald. Metropolitan Plan Making. Philadelphia: Regional Science Institute, Monograph Series Number 4, 1970.

Chapin, F. S. Urban Land Use Planning. Urbana, Ill.: University of Illinois Press, 1965.

Dickey, J. W., F. H. Horton and E. N. Thomas. "Areal Aggregation and Forecasting Precision in Urban Transportation Studies," Tijdschrift voor Economische en Sociale Geografie, 60, 1 (1969), 60 - 62.

Douglas, A. A. and R. J. Lewis. "Trip Generation Techniques," Traffic Engineering and Control, (November, 1970 to February, 1971).

Edwards, J. B. and G. H. Orcutt. "Should Aggregation Prior to Estimation be the Rule," Review of Economics and Statistics, 51 (1969), 409 - 420.

Fleischer, A. "On Prediction and Urban Traffic," Papers and Proceedings of the Regional Science Association, 7 (1961) 43 - 50.

Grunfeld, Y. and Z. Griliches. "Is Aggregation Necessarily Bad," Review of Economics and Statistics, 42 (1960), 1 - 13.

Ingram, D. R. The Concept of Accessibility: A Search for an Operational Form," Regional Studies, 5 (1971), 101 - 107.

Kassof, H. and H. D. Deutschman. "Trip Generation: A Critical Appraisal," Highway Research Board, Record, 297 (1969), 30 - 42.

Lave, L. B. "The Demand for Intercity Passenger Transportation," Journal of Regional Science, 12, 1 (April 1972), 71 - 84.

Martin, B. V., F. W. Memmott, and A. J. Bone. Principles and Techniques of Predicting Future Demand for Urban Area Transportation. Cambridge: M.I.T. Press, Research Report 38, June 1961.

Miller, R. E. (ed.) Studies in Travel Demand. Princeton, N. J.: Mathematica 1965.

Nordbeck, S. "Computing Distances in Road Nets," Papers and Proceedings of the Regional Science Association, 12 (1964), 207 - 220.

Putman, S. H. "An Integrated System of Modes for the Analysis of Urban Transportation Interfaces," Transportation Journal, (Spring, 1971), 29 - 39.

Quandt, R. E. The Demand for Travel: Theory and Measurement. Lexington, Mass.: D. C. Heath, 1970.

Quarmby, D. A. "Choice of Travel Mode for the Journey to Work," Journal of Transport Economics and Policy, (1967), 273 - 314.

Rannels, J. The Core of the City. New York: Columbia University Press, 1956.

Snell, J. and P. W. Shuldiner. Analysis of Urban Transportation Research. Evanston, Ill.: The Transportation Center, Northwestern University, 1966.

Stowers, J. R. and E. L. Kanwit. "The Use of Behavioural Surveys in Forecasting Transportation Requirements," Highway Research Board, Record, 106 (1966), 41 - 55.

Walker, J. R. "Rank Classification: A Procedure for Determining Future Trips Ends," Highway Research Board, Record, 240 (1968).

Warner, S. L. Stochastic Choice of Modes in Urban Travel: A Study in Binary Choice. Evanston, Ill.: Northwestern University Press, 1962.

URBAN GOODS MOVEMENT

Bates, M. V. "The Trucking Industry and Urban Development," Unpublished report, Smith Transport, Toronto, 1968.

Bayliss, B. T. European Transport. London: Kenneth Mason, 1965.

Bayliss, B. T. and S. L. Edwards. Industrial Demand for Transport, London: H.M.S.O., 1970.

Buhl, W. F. "Intercity Highway Transport Share Tends to Vary Inversely with Size of Plant," Highway Research Board, Record, 175 (1967), 9 - 14.

Carey, W. N. "Goods Movement in Cities that are for People", Paper presented at the Sixth Conference of International Road Federation, Montreal, October 1970.

Chintz, B. Freight and the Metropolis. Cambridge: Harvard University Press, 1960.

Church, D. E. "Impact of Size and Distance on Intercity Highway Share of Transportation and Industrial Products," Highway Research Board, Record, 175 (1967), 1 - 8.

Eliot-Hurst, M. E. "An Approach to the Study of Non-Residential Land Use Traffic Generation," Annals of the Association of American Geographers, 30, 1 (1970), 153 - 173.

French, A. and P. Watson. "Demand Forecasting and Development of Framework for Analysis of Urban Commodity Flow," Panel Report, Urban Commodity Flow, Highway Research Board, Special Report 120, Washington, D. C. 1971, 135 - 141.

Goss, D. N. et al. Urban Goods Movement Demand. Columbus, Ohio: Battelle Memorial Institute, 1967.

Grava, S. Intra-Urban Freight Movement: Transportation Linkages and Location Requirements. Unpublished Ph. D. dissertation, Columbia University, 1965.

Helvig, M. Chicago's External Truck Movements. Chicago: University of Chicago Press, Department of Geography Research Paper Number 90, 1964.

Hille, S. J. "Urban Goods Movement Research - A Proposed Approach," Traffic Quarterly, 25, 1 (January, 1971), 25 - 38.

Hoel, L. A. A Study of the Utilization of Trucks for Transport in Urban Areas. Unpublished Ph. D. Dissertation, University of California, Berkeley, 1963.

Horwood, E. M. "Center City Goods Movement: An Aspect of Congestion," Highway Research Board, Bulletin, 203 (1958).

Hutchinson, B. G. "Forecasting Inter-regional Commodity Flows," Paper presented at the NATO Conference on the Application of Operational Research to Transport Problems, Sandfjord, Norway, August 1972.

Keefer, L. E. Urban Travel Patterns for Airports, Shopping Centers, and Industrial Plants. Washington: National Cooperative Highway Research Program Report Number 24, 1966.

Maltby, D. "Traffic at Manufacturing Plants," Traffic Engineering and Control, 12, 2 (June, 1970), 72 - 77.

Miklius, W. "Estimating Freight Traffic of Competing Transportation Modes: An Application of the Linear Discriminant Function," Land Economics, 45, 2 (1969), 267 - 273.

Noortmann, H. J. "Interrelations Between Urban Movement of Goods and Planning of Urban Areas," Paper presented at the Technology Assessment Review, O.E.C.D., Paris, October 1970.

Oi. W. Y. and A. P. Hunter. Economics of Private Truck Transportation. Dubuque, Iowa: W. C. Brown, 1965.

Perle, E. D. The Demand for Transportation: Regional and Commodity Studies in the United States. Chicago: University of Chicago Press, Department of Geography Research Paper Number 95, 1964.

Shuldiner, P. W. et al. Non-Residential Trip Generation Analysis. Evanston, Ill.: Northwestern University Research Report, 1965.

Shuldiner, P. W. and F. E. Horton. "Land Use Linkages," Paper presented to the O-D Committee, 45th Annual Meeting of the Highway Research Board, Washington, D. C., January, 1966.

Shuldiner, P. W. "Land Use, Activity, and Non-Residential Trip Generation," Highway Research Board, Record, 141 (1966), 63 - 88.

Starkie, D. N. M. Traffic and Industry: A Study of Traffic Generation and Spatial Interaction. London: London School of Economics and Political Science, Geographical Paper Number 3, 1967.

Thomas, E. N., F. E. Horton, and J. W. Dickey. Further Comments on the Analysis of Non-Residential Trip Generation. Evanston, Ill.: Northwestern University Research Report, November 1966.

Transportation Development Agency. Urban Goods Movement: Calgary Survey Method, Phase II. Montreal, T.D.A., to be published.

Vernon, R. "Production and Distribution in the Large Metropolis," Annals of the American Academy of Political and Social Science, 3, 4 (1957), 15 - 29.

Wilbur Smith and Associates. Motor Trucks in the Metropolis. New Haven, Conn.: Wilbur Smith, August 1969.

Williams, T.E.H. and J.C.R. Latchford. "Prediction of Traffic in Industrial Areas," Traffic Engineering and Control, (December 1965 to April, 1966).

Wood, R. T. "Measuring Urban Freight in the Tri-State Region", Paper presented at the Technology Assessment Review, O.E.C.D., Paris, April 1972.

INDUSTRIAL LOCATION, STRUCTURE, AND LINKAGES.

Alonso, W. Location and Land Use. Cambridge: Harvard University Press, 1972.

Artle, R. The Structure of the Stockholm Economy. Ithaca, N. Y.: Cornell University Press, 1965.

Bain, J. S. Barriers to New Competition. Cambridge: Harvard University Press, 1956.

Barloon, M. J. "Premium Transportation: A New Influence in Site Selection," Handling and Shipping, (1965), 45-47.

Goddard, J. "Multivariate Analysis of Office Location Patterns in the City Centre: A London Example," Regional Studies, 2 (1968), 69-85.

Greenhut, M. L. Microeconomics and the Space Economy. Chicago: Scott Foresman, 1963.

Greenhut, M. L. A Theory of the Firm in Economic Space. New York: Meredith Corporation, 1970.

Hoover, E. M. Location Theory and the Shoe and Leather Industries. Cambridge: Harvard University Press, 1937.

Hopkins, F. E. "Transportation Cost and Industrial Location: An Analysis of the Household Furniture Industry," Journal of Regional Science, 12, 2 (1972), 261-277.

Isard, W. Methods of Regional Science. Cambridge: M.I.T. Press, 1971.

Martin, J. E. Greater London: An Industrial Geography. London: Bell and Son, 1966.

Massel, M. S. Indicators of Competition. Washington: The Brookings Institution, 1962.

Ratcliff, R. U. The Problem of Retail Site Selection. Ann Arbor, Michigan: University of Michigan, Bureau of Business Administration, Michigan Business Studies 9, No. 1, 1939.

Sakashita, N. "Production Function, Demand Function and Location Theory of the Firm," Papers and Proceedings of the Regional Science Association, 20 (1968), 109 - 122.

Smith, D. M. "On Throwing out Weber with the Bathwater: A Note on Industrial Location and Linkage," Area, 1 (1970), 15 - 18.

Taylor, M. J. "Location Decisions of Small Firms," Area, 2 (1970), 51 - 54.

Thompson, W. R. A Preface to Urban Economics. Baltimore: Johns Hopkins Press, 1965.

Townroe, P. M. "Industrial Linkage, Agglomeration and External Economies," Journal of the Town Planning Institute, 56, 1 (January 1970), 18 - 20.

Webber, M. J. Impact of Uncertainty on Location. Cambridge: M.I.T. Press, 1972.

Wood, P. A. "Industrial Location and Linkage," Area, 2 (1969), 23 - 29.

MARKETING AND PHYSICAL DISTRIBUTION.

Alderson, W. "Marketing Efficiency and the Principle of Postponement," Cost and Profit Outlook, 3, 4 (1950).

Alderson, W. Marketing Behaviour and Executive Action. Homewood, Ill.: R. D. Irwin, 1957.

Alderson, W. Dynamic Marketing Behaviour. Homewood, Ill.: R. D. Irwin, 1965.

Baligh, H. H. and L. E. Richartz. Vertical Market Structures. Boston: Allyn and Bacon, 1967.

Bell, M. L. Marketing: A Maturing Discipline. Chicago: American Marketing Association, 1960.

Bowersox, D. J., E. W. Smykay, and B. J. Lalonde. Physical Distribution Management. New York: MacMillan, 1968.

Bowman, E. H. and R. B. Fetler. Analysis for Production Management. Homewood, Ill.: R. D. Irwin, 1961.

Bucklin, L. P. "Postponement, Speculation, and the Structure of Distribution Channels," Journal of Marketing Research, 2 (1965), 26 - 31.

Bucklin, L. P. A Theory of Distribution Channel Structure. Berkeley: University of California, Institute of Business and Economic Research, 1966.

Clewett, R. M. Marketing Channels for Manufactured Products. Homewood, Ill.: R. D. Irwin, 1954.

Converse, P. D. and F. M. Jones. Introduction to Marketing. New York: Prentice-Hall, 1948.

Diamond, W. H. Distribution Channels for Industrial Goods. Columbus, Ohio: Ohio State University, Bureau of Business Research, 1963.

Elling, K. A. Introduction to Modern Marketing. New York: MacMillan, 1969.

Revzan, D. A. A Geography of Marketing: Integrative Statement. Berkeley: University of California, School of Business Administration, 1968.

Shepherd, W. G. Market Power and Economic Welfare. New York: Random House, 1970.

Staudt, T. A. and D. A. Taylor. A Managerial Introduction to Marketing. Englewood Cliffs, N. J.: Prentice-Hall, 1965.

Stern, L. W. Distribution Channels: Behavioural Dimensions. Boston: Houghton Mifflin, 1969.

Vaile, R. S., E. T. Grether, and R. Cox. Marketing in the American Economy. New York: Ronald Press, 1952.

THE WOOD PRODUCTS INDUSTRY: STRUCTURE AND TIME SERIES CHARACTERISTICS

Alberts, W. "Business Cycles, Residential Construction, and the Mortgage Market," Journal of Political Economy, 70 (1962), 263 - 281.

Campbell, B. E. Population Charge and Building Cycles. Urbana, Ill.: University of Illinois, Bureau of Business and Economic Research, 1966.

Carlson, J. A. "The Production Lag," The American Economic Review, 63, 1 (March, 1973), 78.

Mead, W. J. "Changing Pattern of Cycles in Lumber Production," Journal of Forestry, (November, 1961), 808 - 813.

Reed, F. L. C. "Elasticity of Demand for Wood Products," Paper presented at the Annual Conference of Western Forest Economists, Wemme, Oregon, April 1966.

Rich S. U. Marketing of Forest Products: Tests and Cases. New York: McGraw Hill, 1970.

Ronalds, K. L. A Study of the Distribution System in the British Columbia Building Materials Industry. Unpublished M.B.A. Thesis, University of British Columbia, 1968.

White, D. A. Business Cycles in Canada. Ottawa: Economic Council, Staff Study 17, 1967.

Zivnuska, J. A. Business Cycles and Commercial Forestry. New York: Institute of Public Administration, 1952.

APPENDIX

Standard Industrial Classification. D.B.S. Catalogue No. 12-501, Dec. 1970.

Ind. No.

251 Sawmills, Planing Mills and Shingle Mills. Establishments primarily engaged in sawing lumber (boards, timbers, dimension stock) spoolwood, lath and other mill products such as shingles, cooperage stock and box shook from logs or bolts; in dressing and working lumber to produce standard matched, shiplapped or patterned products. Establishments primarily engaged in manufacturing hardwood flooring and millwork products other than lumber are classified in Industry No. 254.

252 Veneer and Plywood Mills. Establishments primarily engaged in producing plywood or veneer.

254 Sash, Door and Other Millwork Plants. Establishments primarily engaged in manufacturing mill products such as sash, doors, windows and door frames, interior woodwork, mouldings and hardwood flooring. This industry also includes establishments primarily engaged in manufacturing prefabricated, wood-framed buildings or pre-fabricated panels for buildings or in manufacturing laminated beams and structures.

256 Wooden Box Factories. Establishments primarily engaged in manufacturing wooden boxes and pallets, crates, fruit and vegetable baskets. This industry includes establishments making box shook from sawn lumber.

258 Coffin and Casket Industry. Establishments primarily engaged in the manufacture of coffins, caskets, and other morticians' supplies.

259 Miscellaneous Wood Industries. Establishments primarily engaged in wood preservation; in wood turning and in manufacturing wood products not elsewhere classified, including sawdust briquettes. Principal products are beekeepers' and poultrymen's supplies, excelsior, woodenware (clothespins, washboards, stepladders, pails and tibs) sanitary woodwork and particle board. Establishments primarily engaged in manufacturing cooperage such as barrels, casks, kegs, and other containers made of staves are included in this industry.

Furniture and Fixture Industries.

261 Household Furniture Manufacturers. Establishments primarily engaged in manufacturing household furniture of all kinds and of all materials. This industry also includes upholstery, cabinet making and furniture repair shops.

264 Office Furniture Manufacturers. Establishments primarily engaged in manufacturing office furnitures such as

desks, chairs, tables, filing cabinets of all kinds of materials.

266 <u>Miscellaneous Furniture and Fixture Manufacturers</u>. Establishments primarily engaged in manufacturing store furniture and fixtures, public buildings and professional furniture of all kinds and all materials. This industry also includes establishments primarily engaged in manufacturing matresses and springs.

<u>Paper and Allied Industries</u>.

271 <u>Pulp and Paper Mills</u>. This industry includes pulp mills producing chemical or mechanical woodpulp; and combined pulp and paper mills and paper mills manufacturing newsprint, book and writing papers, Kraft paper, paperboard or building and insulation board.

272 <u>Asphalt Roofing Manufacturers</u>. Establishments primarily engaged in manufacturing asphalt-saturated shingles and sidings, roofing felts and sheathings, smooth-surfaced and mineral-surfaced rool roofings.

273 <u>Paper Box and Bag Manufacturers</u>. Establishments primarily engaged in manufacturing shipping boxes or cases made of corrugated or solid fibreboard; folding or set-up paper or paper board boxes; paper bags; fibre cans; decorated and fancy covered paperboard boxes; and paper and paperboard containers not

elsewhere classified. Many establishments included in this industry produce bags and other containers of synthetic materials and of metal foil.

274 Miscellaneous Paper Converters. Establishments primarily engaged in coating, treating, cutting and otherwise converting paper and paperboard. Many of these establishments also use synthetic materials and metal foil to produce articles similar to those manufactured of paper and paerboard. Important products of this industry include waxed paper, crepe paper, paper napkins, envelopes and stationery, gummed paper, wallpaper, paper plates and cups, mailing tubes.