Transport demand models and policy
A Comparative Analysis

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GOALS, OBJECTIVES AND POLICY INSTRUMENTS

A necessary condition for a policy proposition to be valid is the prevalence of consistency among goals, objectives and policy instruments.[1] The intent of this paper, therefore, is to suggest a rational sequence of steps in structuring a set of policy guidelines consistent with a macro framework from which forecasts are derived. Since the transportation sector is a part of such macro framework, it becomes immediately obvious that any given forecast and/or policy proposition must be consistent with the overall structure and objectives of the economy. This means that a sectoral analysis is considered valid, if and only if, it is derived from a consistent macro structure. A case in point is the sequence and the substance of a Strategic Planning Guidelines[2] for the transport sector.

The first step in formulating such document is to explicitly state an attainable choice-set of socio economic goals and objectives, which are relevant to transport planning. Transportation infrastructure is indeed the "nervous-centre" of any market economy, and thus, it contributes to and affected by (directly and indirectly), most of society's goals and objectives. More specifically, goals relating to an increase in society's welfare through:

a. a resource and product mobility
b. income distribution and transfers
c. urban and rural development
d. increased capacity of market diversification
e. technological applications to industrial development resulting in relocation of plant and markets;

are predicated on an existence of a well developed transport and communications infrastructure. It is just natural, therefore, that a cornerstone of the Document would be a consistent set of the economy's goals and objectives from which priorities are to be derived. Such a statement would constitute the first section of the Document, and as such, should set the "ground-rules" for the entire subsequent parts of it. Once the Document is ordered in such a way it lends itself to the derivation of operational policy instructions and instruments at the Ministerial level.

Once a set of national goals is established on the federal level, a corresponding subset of objectives is derived from it. Objectives thus, are operational statements designed to aid the attainment of the national goals. It is interesting to note that an objective defined by the Federal Government becomes immediately a goal to be attained by a particular ministry. Such an objective thus becomes a *policy directive* in an operational sense for the respective ministry. Policy instructions are then derived by the Ministry, and the proper instruments are assigned for the execution of these policy instructions.

The assignment of policy instruments motivates a multi-stage process of monitoring re-examination and reconciliation within the operating ministry. First comes the function of monitoring on-going programs concurrently with bottlenecks which arise within the ministry and relating them to general goals and objectives. Resolution of this stage leads to a completion of the Planning Document draft with a high probability of consistency between goals and objectives, and possibly minimal operational conflicts between the on-going set of programs and the proposed undertakings. The re-examination stage comes next. This stage consists of preliminary budget submission which inevitably presents the planners with a new series of trade-offs and conflicts of choice. Specific analyses and forecasts on the commodity level are required at this stage in order to fully comprehend all probable technical and financial conflicts. A final reconciliation stage occurs at the budget level, where policy directives "from above" (translated into operational departamental objectives) *plus* the effects of monitoring current problems, are formulated as a set of programs with price-tags attached for the final review and approval of the cabinet, via the Treasury Board.

Such multi-stage process results in an approved set of programs, and a final draft of the Planning Document is then considered as a Plan-of-Operation for the operating ministry. The time horizon of the Document determines how detailed such Plan-of-Operation would be, for operationality must be concurrent with budget allocation decisions.

For the sake of clarity and for illustrative purposes, let us develop a logical chain from the national goal level down to the level of Transport Ministry's relevant instruments. Suppose a stated national goal is an improved income distribution in the country, through increased employment. The Federal Government objectives become immediately:

a) to increase income of the poor by x% during the next five years converging gradually to the long run income distribution goal.

b) increase mobility of people and economic activities within and across regions in order to maximize employment opportunities.

Government's instruments to increase income distribution and to induce industrial development and relocation, would be derived from fiscal and monetary policies.

The Federal Government objective (b) becomes however, a proper given goal for its Transport Ministry. It views its derived objective as the removal of infrastructure obstacles due to locational factors. Policy instructions to the Transport Ministry might include:

a) improvement of services to relatively poor regions;

b) an instruction to pursue with shared road programs subject to budget limitations;

c) develop subsidy or grant aid program to facilitate movements of commodities between given origins and destinations.

The Ministry might select the following instruments to execute its policy instructions:

a) monitoring incidents of user charges to examine efficiency vs. income distribution effects

b) monitoring incidents of subsidies

c) allocation of investment programs

Once a rigorours flow from goals to policy instruments is established, we can rationalize the contribution of any given instrument towards an attainment of an upper level objective and goal. Summing up the total effect (results) of the instruments on an assigned goal, we are in a position to assess the contribution of the Ministry to the attainment of national goals and objectives.

Similarly, when we wish to forecast (or estimate) the parameters of a given sector, say transportation, they must be derived from a consistent macro structure or model. In the event that the above procedure is not rigorously thought through there exists a high probability of overlapping and/or contradictory objectives, with some that are irrelevant insofar as they are not capable of generating objectives and policy measures for which policy instruments exist. The role of economic forecast is that one of the inputs — although an important one to the overall planning process. The relevant questions which the forecasting activities would answer are:

a) What is the likely state of the general economic environment which affects the short term trade-offs between long term objectives, and the ability of a department to advance towards the objectives and thus set concrete targets?

b) What are the likely developments of specific transport demands to be dealt with by specific programs?

Clearly, macro-economic forecasts are the relevant tool for answering the first set of questions; specific demand forecasts both at the sectoral (i.e. transportation) level and specific transport demand level require transport sector forecasting model further disaggregated into specific transport markets (i.e. commodity movements) forecasts.

Obviously, there must be internally consistent and sectoral or market forecasts must be derived from a consistent macro-model. If a direct linkage between the sectoral and market (commodity) forecasts and a general macro-model does not exist (as in the case at present), a formal linkage between the macro-model and transport model must be developed preserving the consistency of the assumptions of the macro-model. It should be noted, however, that in reality this ideal state of heirarchial modeling is yet to be attained. That is, in order to construct a transport planning model fully consistent with all other sectors of the economy and the variables within these sectors; all of which are consistent with a national macro model, we must have a set of models gradually disaggregated from a national level to a regional level down to the commodity level. Specifically, this means that as long as the national macro model (in our case CANDIDE) does not contain sub-systems of adequate and consistent regional and commodity disaggregations, we ought to ling our transport model to proxy variables of CANDIDE and rely on some market forecasts where such proxy varibbles do not exist. Thise introduces a serious obstacle to the model builder, for the consistency of the transport model with the main aggregates of the economy must be maintained at all times. The next sections will deal with the rationale of the development, the use and problems inherent in the employment of the forecasting work insofar as it affects the planning activity.

ECONOMIC INPUTS TO THE PLANNING DOCUMENT

This section entertains a central problem confronting planners in the preparation of the Document. Such a problem is the choice of the most desirable forecasting model, from which results are likely to be considered reliable as inputs to the Document. Since the purpose of this paper is not purely theoretical, we would like the reader to accept a priori that the formulation and the estimation of a valid economic model is based upon sound economic and statistical theories respectively.

Historically, the development of the theory of quantitative economic policy laid down by Jan Tinbergen [1] led to the formulation of the first large-scale economic models[3]. These developments provide the foundations for the application of the theory to practical policy making. The development of these models received its principal impetus in the "Keynesian revolution" in economics during the post-war years. The Keynesians focused on the study of the dynamics of the economic system, mainly from the short-term point of view. Although these models have found important uses in the area of short-term economic forecasting, detailed investigation of the structural characteristics of the economic system has also provided us with sophisticated models for use in quantitative economic policy. Three ancillary developments have helped in the construction of large and increasingly sophisticated models of the economy. First, the development of national income statistics and the collection of many other types of economic data, have provided the raw material for macro models. Second, estimation methods developed earlier, most for application to experimental data, have been adapted and refined to deal with more complex and interdependent data in the social sciences and particularly in economics. Third, the computational problems of dealing with large interdependent systems have been facilitated by the rapid development of computers and computer programs.

The type of model that results from the theoretical specification of the equations has important implications for both the ease of estimation and the efficiency of the parameter estimates to predict and form a policy. The benefit from using forecasting model for planning purposes is that it provides a coherent view of the economic environment, and it is capable of tracing changes in the economy during the forecasting period; while maintaining relative consistency among the various elements of the economy. The preceding exposition leads us now to consider the suitable type of model from which results may be obtained for the Planning Document.

In general, there are three different types of models all of which generate quantitative information as inputs to a planning Document. It is thus vital to differentiate among them and to briefly assess their usefulness in terms of the quality of their output.

Purely Projection Models

Purely projection models are the "curve-fitting" type models. They generally contain a set of relationships which have "bound together" different variables. The validity of the specification of such models is no more and no less than that of any linear transformation of the same. In practice such models may be useful for predicting but for obvious reaons they are not a useful tool for economic policy making. The specification in this case does not necessarily indicate the direction of causation, nor the direction of influence among the variables. The dominant assertion in such models is merely a proposition of functional relationship among variables which seem to correlate with one another. More often than not, the variables which are repeatedely seen in such models as independent variables are Gross National Product, Population series and Time; all of which appear to be highly correlated with a continuously increasing dependent variable. It is obvious that we strongly advise planners to avoid the use of results from purely projective model (i.e. time trend forecasts) as reliable inputs to Planning Document. It would obviously lead to an inconsistent set of projections and consequently to misleading policy recommendations.

Structural Models

In structural or explanatory models the specification must be such as to indicate the direction of the influence among the variables. The model builder is asserting more than a merely functional relationship among the variables. Causality is therefore infered in terms of stimulus-response mechanisms; thus causal relationships are asymetrical and irreversible except in special cases. In probability terms, the distribution of "y" is causally conditional on the realization "x", but not vice versa. In this definition of causality we have in mind the implication of control. Thus, "y" is causally dependent on "x" if the probability distribution of "y" can be controlled by specifying a value for "x". This explanation of causality is in somewhat pragmatic terms and based on controllability, and can be carried over with great effect into the interpretation of recursive systems. A recursive system may be written in the form:

$$B_{y'} + G_{z'} = u'$$

where

$$B = \begin{bmatrix} 1 & \beta_{12} & \beta_{13} & \cdots & \beta_{1g} \\ 0 & 1 & \beta_{23} & \cdots & \beta_{2g} \\ 0 & 0 & 1 & \cdots & \beta_{3g} \\ , & , & , & , & , \\ , & , & , & , & , \\ , & , & , & , & , \\ 0 & 0 & 0\ 0\ 0 & 1 & \beta_{g-1,g} \\ 0 & 0 & 0\ 0\ 0 & 0 & 1 \end{bmatrix}$$

$$G = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \cdots & \gamma_{1k} \\ \gamma_{21} & \gamma_{22} & \cdots & \gamma_{2k} \\ \gamma_{31} & \gamma_{32} & \cdots & \gamma_{3k} \\ , & , & \cdots & , \\ , & , & \cdots & , \\ , & , & \cdots & , \\ \gamma_{g1} & \gamma_{g2} & \cdots & \gamma_{gk} \end{bmatrix}$$

and

$y = (y_1, y_2, \ldots, y_g);$
$z = (z_1, z_2, \ldots, z_k);$
$u = (u_1, u_2, \ldots, u_g)$

where the y's are causally dependent variables, the z's are the predetermined variables, and the u's are stochastic variables which are statistically independent. Each error u_j is assumed to be statistically independent of $y_{j+1}, y_{j+2}, \ldots, y_g$. The variables with unit coefficients are regarded as the resultant variables and the other y's and z's are regarded as causal variables. If it is actually possible to control a variable y_j through the manipulation of the other y's appearing in the jth equation, all that is necessary is to strike out this equation and reclassify y_j as a predetermined variable rather than as a dependent variable. The coefficients of y_j in the other equations remain the same as before.

This is the causal interpretation of the β's in the recursive system. Thus the values of the coefficients describe the influence of the causal variables on the resultant irrespective of whether the former are dependent or predetermined. No such causal interpretation is possible in the general interdependent system. In a certain sense, the vector z may be said to cause the vector y. This is immediately seen from the reduced form:

$$y' = -B^{-1}Gz' + B^{-1}u'$$

but the reduced form tells us nothing about the inter-relationships among the y's. For purposes of prediction this model is useful, since it enables us to predict the effect on y of controlled variations in the predetermined variables.

It may, however, be possible to partition y into subsets such that a conformal partitioning of B results in a block-triangular matrix:

$$y' = (y_1\ y_2\ y_3)'$$

and

$$B = \left[\begin{array}{c:c:c} B_{11} & B_{12} & B_{13} \\ \hdashline 0 & B_{22} & B_{23} \\ \hdashline 0 & 0 & B_{33} \end{array}\right]$$

In this case, y_2 is caused by y_3, and y_1 is caused by y_2 and y_3 together. However, since the relations within the subsets are not recursive, no causal explanation within subsets is possible. This extension of causal systems by Herbert Simon [2] advances the mode of causal interpretation from macroeconomic models much further, because block-triangular structures are more likely to occur than purely triangular ones [3].

Since we are committed to examine the usefulness of structural models to the process of economic planning and in particular to transport planning, we ought to pursue the discussion one step further. It is clear at this point that a structural model is a representation of economic behavior which is based on economic theory, the outgrowth from such theory (or theories) is a set of hypothese to be tested statistically, from which conclusion of validity or nulification of such hypotheses are drawn. The most important element in structural models is that the dependent variables (y's), are always explained by economic variables (x's) and policy variables for we seek an explanation of causation rather than correlation, as projection model do. This leads us to an in-depth understanding of the interdependence relations in the economy, and only then we may decide whether or not to accept our forecasts as reliable input to policy planning.

Suppose a structural model has satisfied all the conditions posted above, how can we utilize it in transport planning? An answer to such question is relatively straigthforward, a proper forecast of transport variables while capturing the interrelationships of transportation with the rest of the economy, could be performed *only* with the aid of an integrated hierarchial set of structural models. We shall thus term such hierarchial structure as a Forecasting Framework or as the already coined name to it a Forecasting Program[4]. Such Forecasting Program should involve three major elements which must evolve one another.

1. A consistent analysis of the economy and a forecast of probable range of its development.
2. A detailed set of sectoral forecasts which carry significant impact on the use of transport services.
3. A forecast of transport demand generated by the change in sectors of particular significance to transport.

The problem now becomes how to order logically and effectively the available building blocks of forecasting to coincide planning steps, and this is the subject of our next section. In closing, we strongly endorse the use of structural models for policy planning for their results are defendable on more solid grounds than any other type of forecasting models.

Intuitive or Descriptive Models

These models are generally offered by "experts" in particular industry or of particular commodity. Results from such models are often a consequence of simple extrapolations, or based on "personal feelings" or experience. Since it is a partial judgement relating to specific sub-sector or commodity, consistency with the rest of the economy is practically impossible. We therefore suggest that only at the extreme case of unavailable data such approximations be considered as inputs for planning.

A Digression on The Nature of Structural Econometric Models [5]

Whether for use of forecasting or for policy analysis, the structural models we employ are complete systems of equations; that is, they consist of as many equations as there are endogenous variables. Each endogenous variable must occur in its current or unlagged form in at least one equation, and the structure specified by the complete set of structural equations must be uniquely identifiable. For this reason, alle the parameters of each structural equation must be uniquely dentified within the model specified; that is, the parameter must have the same value for all equivalent structures contained in the model. When all parameters have been identified, the model is ready for use.

The necessary condition for the identifiability of a structural equation within a given linear model of N-equation is that the number of endogenous variables excluded from the equation must be at least one less than the number of equations. If the coefficients of these excluded variables in the other N-1 equations of the system form at least one non-vanishing determinant of order N-1, we then have the necessary and sufficient conditions of identifiability. Given the conditions, the system of equations can be solved for the values of the endogenous variables in terms of the predetermined variables, both the exogenous and the lagged endogenous variables. The coefficients of these reduced-form equations are always identifiable, being parameters of the joint distribution of the observations. In certain cases an originally unidentifiable system can be rendered identifiable by the introduction of specific explanatory variables, but these must be specified on the basis of valid economic theories and not merely to apply available tools of statistical analysis. An example of this is Ezekiel's [4] estimation of an investment schedule by partitioning investment into four components and introducing as two new exogenous variables (1) the cyclical component of housing investment and (2) the exogenous component of net contribution from foreign trade and the government budget as explanatory variables.

MACRO ECONOMIC FORECASTS

Two points should be emphasized at the outset of this section:

a. Macro forecasts should not be used as inputs to the Document *unless* the underlying macro model from which these results were derived is completely consistent with the official set of National Income Acounting System, and it contains all the sectors of the economy[6].

b. One must keep in mind that a "super-model" which is constructed to solve *all* economic planning problems does not exist: that is, each model is built with the intent to focus on a particular set of problems, i.e., international trade, monetary questions, growth and others.

An awareness of (a) and (b) leads us immediately to the most important "don't-do" rule for planners which is, "if you want your set of forecasts to be consistent and reliable ingredient of your Document, do not 'assemble' it from a number of different models". That is the macro model which in view of the users is most suitable for their purposes should be selected and only its results should be used as a basis for the macro analysis. The available macro models in Canada are CANDIDE, TRACE and the various versions of RDX. Each of these econometric models has certain strengths and weaknesses [5] with respect to its sensitiveness to economic changes, disaggregative abilities to sectors and industries, and its focal point of forecasts.

The Bank of Canada RDX, for instance, was designed to concentrate primarily on the monetary aspects of the economy. It would then be a mistake to use RDX for the analysis of the production sector of the economy.

CANDIDE and TRACE are basically structural models encompassing all the sectors of the economy. CANDIDE is the larger model of the two, and furthermore, it was designed to be disaggregated at most to industry forecast level. It is imperative therefore, to study carefully the advantages and the shortcomings of these (and possibly others to come) macro models prior to the use of their various forecasts.

Since CANDIDE is an intra-governmental project and it was designed to produced medium-term forecasts, it is reasonable to consider its results as *macro* inputs for the Planning Document. Some of the shortcomings of using CANDIDE to "drive" our Transport Forecasting Model (TFM) are discussed in the next section of this paper.

THE TRANSPORTATION FORECASTING PROGRAM

If one wishes to forecast the demand for transport on a commodity group level, the problem becomes one of model integration. This means a creation of a scheme where micro level could be forecasted while accounting for all possible macro impacts.

In order that TFM would constitute a continuous sub-structure of CANDIDE, there are at least three conditions which should be satisfied: a) there must exist a correspondence between those endogenous variables of CANDIDE which appear as exogenous ones in TFM; b) a correspondence between the degree of regional disaggregation in TFM and CANDIDE must exist if the values of the latter are to be used in the first; c) a broad commodity breakdown should exist in CANDIDE, as to provide a feasible link with TFM's more detailed commodity groups (by close proxy).

Condition a) is satisfied and implemented in TFM for the last two years. This, of course, provides the conditions to obtain sectorial forecasts of TFM while preserving the internal consistency of the economy's structure via CANDIDE.

Condition b) is not yet fulfielled for it calls for a proper regional disaggregation of CANDIDE. Such a project is on its way for the last two years (CANDIDE R), and hopefully would be operational in the near future.

Ultimately, however, a transport model which intends to generate forecasts on a regional level should be "driven" by or linked with a proper regional development macro model. The benefits from such a link are far reaching and beyond the scope of this paper.

Condition c) is not yet satisfied for CANDIDE's disaggregation does not extend beyond the sectorial level.

A short description of the CTC[7] Transport Forecasting Program might illuminate some of the problems which are related to the attainment of such macro-micro continuum (i.e., a complete mapping from CANDIDE into TFM). It will also expose the reader to certain plausible "second-best" solutions which we have attempted in order to overcome inevitable gaps in such continuum.

By way of illustration let us pose the following set of questions that TFM as a sectorial model could satisfy.

1. To what extent there exists a correspondence between the demand for commodities and sectors (and thus derived demand for transportation), and the existing differential rates and patterns of regional growth in the country?
2. What are the major determinants of derived demand for transport within a given region, given variations in economic activities within the region?
3. What is the interactive nature of certain commodity groups and different transport modes? That is, the complementary, substitution or competetive relations which exist in the economy, and the implications derived from them to a realistic planning of infrastructure for different modes. Here elasticities and cross-elasticies of derived demand are instrumental to a better understanding of such planning problems.
4. To what extent transport cost policies be effective in increasing commodity flows among regions, and thus affect employment opportunities in such regions.

In order to relate to such questions (or problems) while showing the way in which we overcome some of the discontinuities between CANDIDE and TFM, we should point out how these two models interact in the actual process of estimation.

The structure of the CTC model fulfills the conditions put forth in the previous section of this paper. It is a structural forecasting model where causality in it is well defined. Moreover, it was built as a satellite model of CANDIDE in order to maintain at all times consistency with the economy's major aggregates.

The CTC model (TFM) is a multi-model medium term econometric model. It contains 23 groups of equations each of which represents a commodity group and designed to forecast its demand of freight flows across regions in Canada, as well as imports and exports to and from the rest of the world.

These forecasts are disaggregated into five domestic regions and to Canada's major trading countries, (each country represents a region). It thus becomes obvious that one TFM's focal points is to identify regional differences of commodity flows and to provide a structural explanation for it [6].

The basic structure of the model incorporates three modes, rail, marine and trucking, although the last mode has not yet been empirically tested due to data limitations.

The model is based on the assumption that flow of goods from a region of origin "i" to a region of destination "j" is determined by identifiable economic factors. Thus we explain commodity flows among regions, on the supply side, by excess production or "push" variables (EP_i), and on the demand side, by excess consumption or "pull" variables (EC_j). In addition to these economic variables we use transport rate as a "friction variable", for it either induces or impedes traffic flows along various links.

The general form of the model

$$T_{ij} = f(EP_i, EC_j, R_{ij}) \tag{1}$$

where

T_{ij} denotes transport flows in tons for a given commodity along the link, with origin i and destination j.

EP_i and EC_j represent vectors of "push" and "pull" variables respectively, and R_{ij} is a vector of rates along various links. For any given link with origin i and destination j we have

$$T_{ijt} = \alpha_{ij} + \beta_{ij}EP_{it} + \gamma_{ij}EC_{jt} + \delta_{ij}R_{ijt} \tag{2}$$

where the "push" and the "pull" variables are vectors and the R_{ij}(rate) is a variable.

For a given commodity, where all links are estimated simultaneously we have the following

$$T_{ijt} = \sum_i\sum_j \alpha_{ij} + \sum_i\sum_j \beta_{ij}EP_{it} + \sum_i\sum_j \gamma_{ij}EC_{jt} + \sum_i\sum_j \delta_{ij}R_{ijt} \tag{3}$$

which becomes our system of equations over all the transport links. In practice, such an unconstrained model is unmanageable due to (a) the number of parameters to be estimated in a combined time series — cross sectional analysis; and (b) due to the short time series available to allow adequate degrees of freedom in order to obtain stable estimates for each link in the system. We then constrain

$\beta_{ij} = \beta_i$ for all j

$\gamma_{ij} = \gamma_j$ for all i

$\delta_{ij} = \delta$ for all i and j

assuming that if our "pull", "push" and rate variable generate similar effects on both points of origin and destination, shippers and receivers of goods are indifferent with respect to their points of destination and origin respectively.

The system of equations (3) thus becomes

$$T_{ijt} = \sum_{i\,j} \alpha_{ij} + EP_{it} + EC_{jt} + \delta R_{ijt} \tag{4}$$

which is far more manageable form to be estimated. The interdependence among the different modes is accomplished in the following way:

Let

TR_{ij} denote a rail link from i to j

θ denote "push" and "pull" variables

TR_{lk} denote interdependent rail movement

TM_{lk} denote interdependent marine movement

TT_{lk} denote interdependent truck movement

and l, k range over all modes.

We specify a rail movement from i to j to be

$$TR_{ij} = f(\theta, TR_{lk}, TM_{lk}, TT_{lk}) \tag{5}$$

A marine movement from i to j is

$$TM_{ij} = g(\theta, TR_{lk}, TM_{lk}, TT_{lk}) \tag{6}$$

and for truck movement from i to j we write

$$TT_{ij} = h(\theta, TR_{lk}, TM_{lk}, TT_{lk}) \tag{7}$$

Interdependent movements result generally in one of the following relations:

$$\begin{aligned} &\text{a. substitutes where } \frac{\delta L_1}{\delta L_2} < 0 \\ &\text{b. complements where } \frac{\delta L_1}{\delta L_2} > 0 \\ &\text{c. independent where } \frac{\delta L_1}{\delta L_2} = 0 \end{aligned} \tag{8}$$

where L_1 and L_2 represent two links.

We thus introduce into our multi-model system the possibility of either complementarity or competitiveness. The final form of our Transport Model becomes now

$$T_{gijmt} = \alpha_{gijm} + \beta_{gim}EP_{git} + \gamma_{gim}EC_{gjt} + \delta_{gm}R_{gijmt} + \sum_{i',j',m'} \psi_{gijm} V_{gi'j'm't} \tag{9}$$

$g = 1, \ldots G;\ \ i = 1, \ldots, I_g;\ \ j = 1, \ldots, J_g;$
$m = 1, \ldots M_{gij}$

and the $\sum$ is over all relevant complementary or competing origins i', destinations j', and modes m'.

We have $N = \sum_{g=1}^{G} \sum_{i=1}^{I_g} \sum_{j=1}^{J_g} M_{gij}$ equations in (9), where G is the total number of commodities, I_g is the total number of origins for commodity g, J_g is the total number of destinations for commodity g, M_{gij} is the total number of modes for commodity g, origin i and destination j.

To satisfy the constraints β, γ, δ we must pool data over different origins and destinations, and thus we work with time-series — cross-sectional data.

Most of TFM's exogenous variables, however, are endogenous in CANDIDE. It becomes obviously clear that the most logical linkage between TFM and CANDIDE would be through the integration of TFM exogenous variables.

What has been done for the last two years and seems to work well is the following procedure:

a. A scenario of the major aggregates which are relevant to TFM is selected and processed (run) through CANDIDE structure. The process leading to a selection of a given scenario involves a thorough examination of several 5-10 years optimal scenarios offered by CANDIDE. Such options vary considerably in the annual rates of growth of the economy's aggregates, ranging from very optimistic to pessimistic states of the economy in years to come.

b. The resulting forecasts of the selected scenario which are fully consistent with the set of national accounts, are being used as inputs into TFM. This simply means that instead of assigning arbitrarily linear rates of growth to TFM exogenous variables, they are being estimated endogenously in CANDIDE, accounting for domestic and international impacts on each and every variable. These variables become the "movers" of the TFM model maintaining sectoral and macro consistency with final demand of the economy.

c. Each of these forecasted variables is then linked with TFM by the use of proper function which establishes a direct transformation of the variables from CANDIDE into TFM. Once such a link is executed TFM becomes a micro extention of a macro model (CANDIDE in this case) and this is wat internal consistency is all about.

So far we have satisfied a condition of a sound continuity between national and the sectorial models. The element of a "second-best" solution lies in the fact that not all TFM's exogenous variables have exact counterparts in CANDIDE. In such cases the transformation function uses the closest proxy variable in CANDIDE which seems to be highly correlated to that of TFM.

By completing the above task of consistency and having on our hands a causally integrated transport model for two modes (Rail and Marine), we can see that answers to question (3) can readily be generated by TFM for planning purposes.

In the absence of an operational regional model we have derived answers to question (1) by proxy. That is, our model contains a set of production, consumption and income variables (personal disposable income) of each of the model's regions. On the supply side production variables are generally used as a point of origin variables, where on the demand side consumption and income variables are used as a point of destination ones.

Assumptions regarding the expected rate of growth of such variables are then drawn by the Forecasting Team. Such assumptions are based on market judgements, interviews conducted by team member in the various governments, and Statistics Canada data analysis. Such assumptions are then imposed on TFM and simulated, without disturbing the overall model consistency.

So far the results are far better than other "ball-park guesses" available on the market, and for a simple reason. Our results are reflecting probable changes in all other variables of the model for the total is always maintained in accordance with the final demand figures. In short, none of the "independent forecasts" are as consistent as ours with the rest of the economy.

Our method will be much improved when a set of regional accounts coupled with regional economic models will be available to "drive" our transport demand model.

ALTERNATIVE APPROACHES TO TRANSPORT DEMAND MODELS (FREIGHT)

1. The essence of an economic model is the simplification of the complex reality. This does not imply that models cannot be highly complex — however, regardles how complex a model is, it still is simpler than the reality it attempts to represent. Every simplification produces its own set of distortions; every model can be attacked on the grounds that it "distorts the reality", but such a general criticism is meaningless. The sensible problem statement clearly is: does the model in question preserve the essential features of the reality which are of interest to the prospective user? This does not preclude the indirect, potential usefulness of general explanatory models, where no specific user is considered. Such models may indeed provide the essential general overview of the pattern of relationships, which later have to be studied in greater depth from a specific point of view, for a specific purpose.

2. From that general statement, a general taxonomy of demand models according to objectives perceived can be derived; an approach to such general taxonomy of transport models is given below:

1. General transport demand models

1. Analysis of generalized relationships in "qualitative" terms.

2. Quantitative analysis of basic relationships affecting demand for transport.

2. Specific purpose transport demand models

1. Transport demand models forming a part of transport (investments) planning models

2. Transport demand models timed at the examination of *effects of the use of* specific "policy instruments", e.g.

(a) Pricing policies — rate regulation; user charges; operating subsidies

(b) Policies affecting the supply of facilities (infrastructure) and/or investments in equipment (equipment subsidies)

(c) Policies affecting competitive position of carriers or modes through licencing, restrictions, etc..

3. An alternative manner of classifying models in the area of transport demand analysis is in terms of *approach.* Two extreme ways of approaching the problem are:

1. The basic intellectual "building block" is the analysis of *individual* transport decisions, i.e. decisions:

(a) to ship or not to ship? and/or how much to ship and at what cost?

b) How to ship? i.e. modal choice

2. The basic unit of observation and analysis are the existing commodity, place and mode (carrier) specific flows. The questions asked are: what are the factors responsible for the existence of observed flows? and — this leads us to the realm of conditional or structural forecasting — if the factors responsible are changed, how will the flows be affected?

Clearly, a number of intermediate approaches is possible.

4. A comprehensive survey of transport demand models would be an enterprise of very considerable scope. In view of the fact that most of the empirical work was sponsored by governmental or international agencies to deal with specific problems, not all of the experience thus gained is directly transferable, and in many cases, not even documented in a manner adequate for professional discussion by outsiders. This is especially true in the case of work done "inside" of governmental offices or done by consulting firms (in the latter case, the "proprietary" interests of model builders were not necessarily conducive to the full description of the work performed). Furthermore, the range, the scope and the number of projects would make a full survey either too long or too superficial.

Thus the practical approach, adopted here, is to apply high selectivity and to concentrate on the key methodological issues.

5. To a very large extent, serious development of large scale transport demand models was affected by the planning of transport systems in less developed nations. The reasons for that were:

(a) Transport systems in developed countries *appeared* to be more mature and thus an incremental approach more acceptable.

(b) International lending and development agencies have quite early insisted on preparation of comprehensive economic plans both at the national and sectoral level.

The pressure for comprehensive planning arose from the desillusionment with specific, individual project evaluation approach,

> "A more integrated and comprehensive approach to transportation planning and analysis is aimed at three principal deficiencies in the present project approach:
>
> 1. Total system effects are not considered in the evaluation of single projects.
> 2. The transportation plan is not related to the overall economic plan.
> 3. Different effects of alternative pricing policies are not considered in conjunction with investment decisions". [7]

This development has not been restricted to the transport sector. A recent thoughtful article on demographic working models contains the following observations which are directly relevant to the present discussion —

> "*Aims of the Models*
>
> "Wat do these models [large scale economic-demographic computer models] do? Their primary purpose, as seen by model builders, is to aid planners in policy evaluation. This aim is expressed differently in each model, but it is common to all. . . .
>
> "Other aims are occasionally stated - for example, to help maintain consistency of planning in different sectors and to point up areas where further research and data are needed. The main purpose, however, remains that of 'policy evaluation'."
>
> "Model builders justify the use of expensive computer models in policy evaluation by arguing that development processes are too dynamic and complex for the unaided mind to foresee with any degree of confidence. . . .
>
> "It will be useful for our purpose to split 'policy evaluation' into two related but distinct parts: qualitative and numerical evaluation. Qualitatively, simulation models aim to spell out the sequence of events that follow particular policy choices and make planners more aware of subtle and unforeseen implications. Their function is to illuminate discussion on policy choice, serving, for any particular issue, as a framework for debate. Numerically, models add to policy evaluation precise figures on the outcome of particular strategies. When budgetary trade-offs are involved. . . this aspect becomes particularly important." [8]

6. One of the most influential attempts to develop a comprehensive transportation model was the Harvard Transportation and Economic Development Program initiated under the direction of John R. Meyer and financed by a research grant from The Brookings Institution. It must be noted that a number of models emerged from this project or were inspired by the original "Harvard Model" methodology which were developed by analytical groups outside of the original project, thus the common usage often confuses the "Harvard Model — proper", i.e. the model which initially emerged from the project (sometimes referred to as "The Brookings Model"), and a number of mutations which claim their direct descendence from the Harvard model.

The basic structure of the Harvard model consists of the following interrelated parts:

(i) the transportation model (or submodel) "which determines inter-regional flows, the actual level of transport facility usage, real (social) costs of providing the transport service, as well as the realized total cost to the user of the transport system"

(ii) the general economic model aimed at explaining the factors which ultimately determine transport flows. It "interrelates general economic variables like prices, incomes, consumption, savings, investments and profits, and specifies the appropriate regional or industry location. All activities, including resource extraction, intermediate goods processing and the production of final goods are included in this general model"

(iii) policy variables, i.e. explicit statement of variables assumed to be under control of the policy maker which affect directly, or indirectly, demand for transport

(iv) the relationship between the transport sector and the "general economy" is twofold:

(a) "Transport charges and congestion costs (e.g. inventory costs to overcome time delays and interest charges on loans to cover goods in transit) are reflected in the industry production costs and in the prices of final and intermediate goods. Also . . . the availability of transport facilities . . . or the existence of regional differences in transport costs, can make one region more competitive than another in particular markets thus leading to regional differences in growth" [9].

(b) Investment in the transportation sector require specific inputs (material, services, labour) which affects the demand for such goods and employment levels. (It sould be noted that the regional distribution of such demands need not correspond to the location of transport investments[8]. For diagramatic presentation of the working of the Harvard model, see fig. 1.

A different view of the Harvard model is:

(a) A general macroeconomic model is used for the forecasting of inter-regional flows.

(b) The macroeconomic model is directly connected with network optimization and investment optimization models.

(c) The model is "partially opened", i.e. "policy variables" are independently specified and they react both on "transport" and "general economic" parts of the model.

Thus the understood "Harvard model" provides a general framework for policy evaluation analysis — and thus is a "normative" rather than "descriptive" or "positive" model. It is not *per se* a forecasting model, but forecasting of traffic flows is the key part of the apparatus, and, by exposing the interrelationship between "general economic" and "transport" variables, the model provides also a framework for demand forecasting program.

7. As it was already noted, the "Harvard Model" produced a number of specific mutations. In general, the reasons for the mutations related to the gluttonous data requirements which were not satisfiable in practice. For example, the "Dahomey model" developed by N.D. Lea and Lamarre-Valois for the IBRD sponsored project in Dahomey, used the following analytical sequence:

(a) Demand for transport was derived from specific projection of key exports and imports, allocated to specific areas.

(b) Projected sectoral demands were used as inputs into network and investment optimization models.

8. Applications of this type of model to trans-

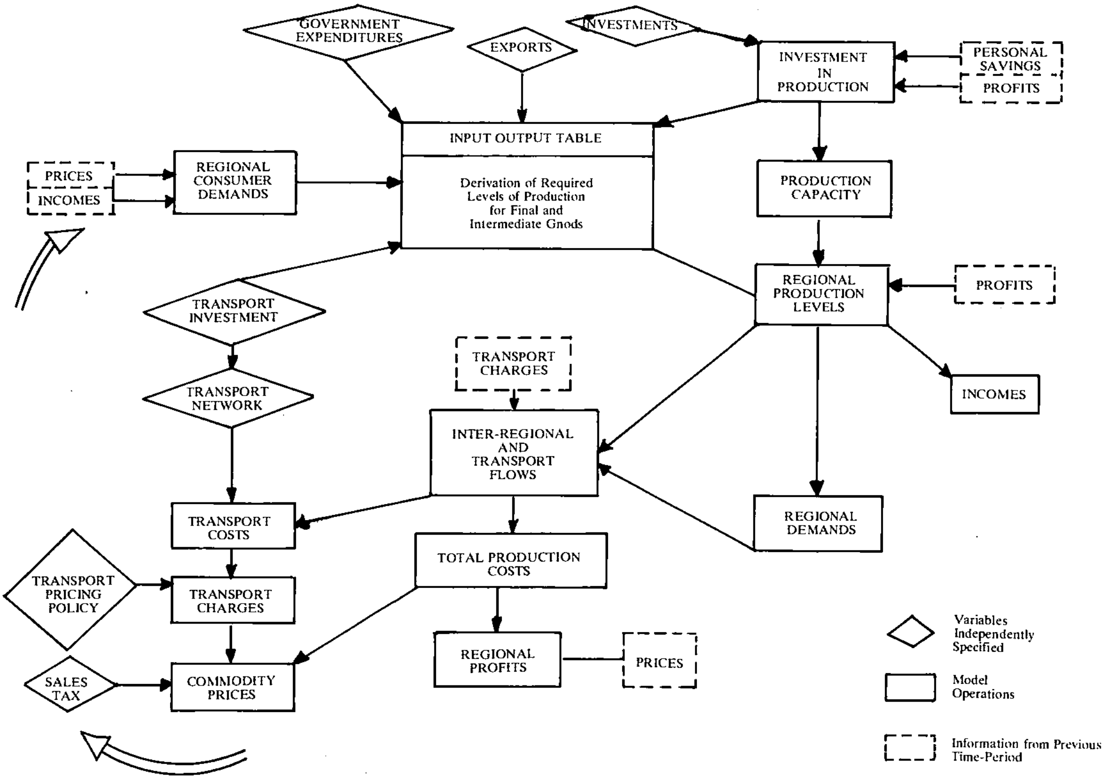


Figure 1 - Major Phases of Model Operation

port planning in an advanced and complex area involves another set of difficulties:

(a) Capacities of the transport system are extremely difficult to define, let alone measure.

(b) Given the widespread existence of joint and common costs, as well as differences in cost structure and supply objectives in different sectors of the system;[9] from the users point of view, the relevant costs are "tariff rates" and "user charges" which may or may not reflect "real costs", and which are by themselves the manifestation of investment and pricing strategies of different decision making units.

In short, the complexities of modelling the supply side — which affect the *observable* level of traffic flows — introduce new difficulties both for the construction of demand models and policy evaluation models[10].

9. Let us now turn to a basically different set of transport demand models, which were inspired by classical location theories. The questions asked by location theorists are of two types:

(i) What determines the location of economic activity (or its rate of growth) at a particular point or in a particular area?

(ii) What are economic consequences of location of economic activity or of growth of economic activity at a specific point or a specific area?

This leads to more specific transport questions:

(a) If we want to develop economic activity (or accelerate its development) at a specific point or in a specific area, can this development be affected by transport policies, and if so to what degree, at what cost and what mix of transport and non transport development instruments is most effective?

These issues can be narrowed down to a more specific analytical question: what is the role of transport in the development of economic activity in a specific location?

(b) What are the transport consequences of developing certain activity (or set of activities) at a specific location? In the econometric terms, the function to be estimated is

$$\begin{array}{l}\text{Demand for}\\ \text{transport TO}\\ \text{or FROM x}\end{array} = f\left(\begin{array}{l}\text{Growth of}\\ \text{activity(ies)}\\ y_1, y_2 \ldots \text{at x}\end{array}\right)$$

In practice, this leads to two sets of demand problems, viz.

(i) transport demand related to the expansion (in volume and/or geographical extent of the trading area) of production at x. ("Market area" problem)

or (ii) transport demand related to the growth of consumption (including local production) at x — ("Supply area" problem).

Transport demand analysis (or analyses) in this context is essentially partial, and difficult to integrate with network analysis.

However, some interesting results may be obtained from that type of analysis. In fact, very specific transport demand models can be viewed as members of this "analytical family" (e.g. models aimed at estimating automotive traffic generated by shopping centres, models aimed at estimating transport requirements of "new", remote mining communities. Furthermore, "transport demand models" geared to the analysis and forecasting of traffic at a terminal point (be it a point of origin or destination) have considerable utility in themselves, since a number of transport investment decisions relate to terminal facilities problems.

10. It appears to be useful, at this stage, to consider briefly the manner in which "location effect models" are constructed. Only general considerations, rather than specifics of model construction are considered.

The simplest formulation of the location effect model is as follows:

$$T_{dx} = f_x(c_1, c_2, \dots c_i; p_1, p_2, p_3 \dots p_i; s_1, s_2, \dots s_i)$$

$$T_{ox} = g_x(p_1, p_2, \dots p_i; s_1, s_2, \dots s_i)$$

Where Td and To are respectively traffic flows destined to and originating at the location studied; x is a commodity or a group of commodities which is being investigated.

$c_1, c_2, \dots c_i$ are the consumption activities, or characteristics determining consumption levels (by commodities).

$p_1, p_2, \dots p_i$ are the production activities or characteristics determining production levels (by commodities)

$s_1, s_2, \dots s_i$ are the stock levels.

A moment of reflection reveals that the above formulations do not include any transport variables — such as transport costs, congestion costs, etc. and that, in fact, such variables cannot be directly introduced without further elaboration of the model. For example, let us assume that x is the commodity group "foodstuffs" then variables $c_1, c_2, \dots c_i$ in function

$$T_{d(\text{foodstuffs})} = F_{(\text{foodstuffs})}(c_1, c_2, \dots c_i, p_k, s_l)$$

can be population, income per head, average price of food, etc., p_k is production and s_l is storage of foodstuffs. After estimating the values for the specified variables, we can estimate the elasticities of demand for transport with respect to population, income, etc. but not the effects of changes of transport rates, except to the extent they influence the price level of foods. The reason for that is that without specification of points of supply, transport costs are not determinable. A possible way out is to define commodities in such a way as to distinguish explicitly their point of origin, e.g. commodity x would not be "coal", but "coal produced in Alberta". Once this reformulation is admitted, a much more interesting model can be derived.

For example, we are interested in transport implication of the establishment of industry producing widgets at a point P. The generalized production for widgets[1] production at P is

$$P(x_1, x_2, x_3, \dots x_n; y_1, y_2, \dots y_n; \pi_1, \pi_2, \dots \pi_n)$$

where $x, \dots x_n$ are inputs and $y_1, \dots y_n$ are outputs. Inputs are defined as being location of supply specifically i.e. physically the same inputs coming from different points are defined as different inputs. $\pi_1, \pi_2, \dots \pi_n$ are input prices, including transport costs.

In this formulation, price of an input coming from "outside", π_k, can be decomposed $\pi_k = \pi_{k(0)} + \pi_t$, i.e. price at the origin and transport costs.

If adequate information is available to estimate this production function, it could provide us with interesting information on substitution both between inputs and points of origin.

Similarly, we can write the demand function for a consumption good y at point p as follows:

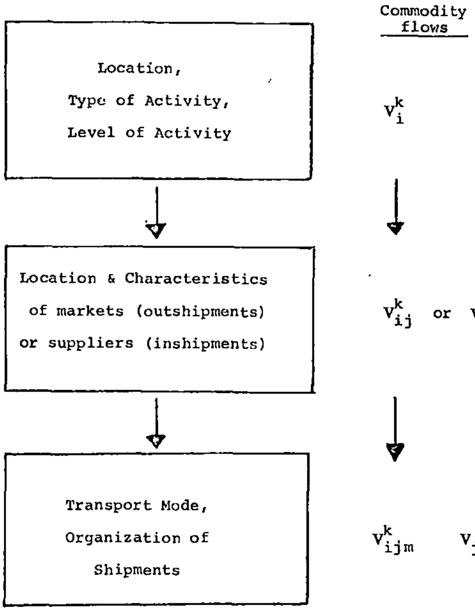
$$Q_{yp} = Q(\pi_y, \pi_{yk}, i, u_r)$$

where π_y is price of a consumption good y, π_{yk} are prices of "competitive" consumption goods $(k = 1 \dots n)$; i — income, and u_r $(r = 1 \dots n)$ — other relevant socio-economic factors.

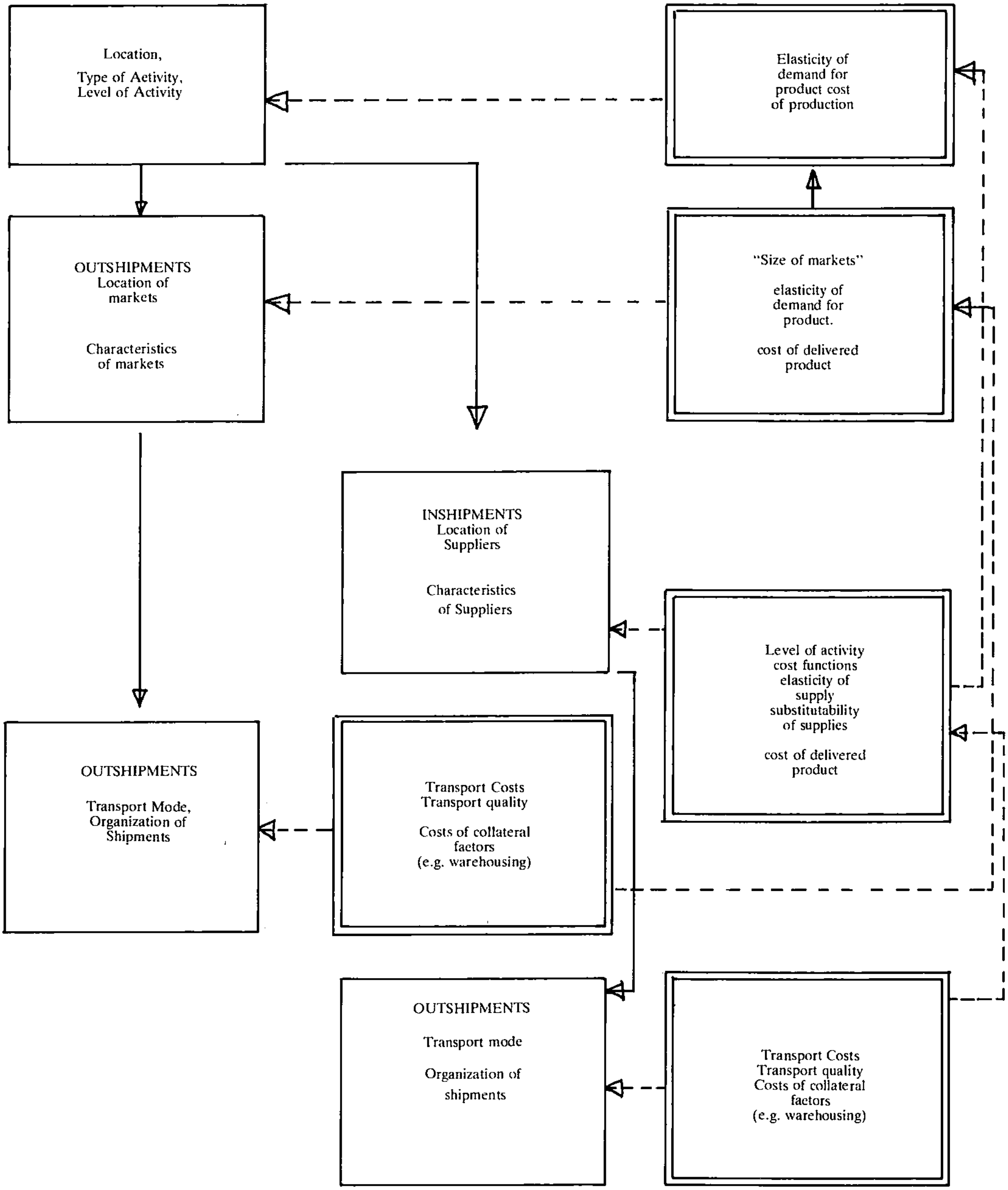
Obviously, in the case of an "imported" consumption good $\pi_{y(p)} = \pi_{y(0)} + t$ — i.e. price at P equal price at point of origin plus t — transport and related costs. For reasons of analytical convenience, goods produced at different points of origin are treated as "different goods", whether the consumer perceives such goods as "identical" or perfect substitutes is reflected in demand cross-elasticities. If goods are perceived, the distribution of supplies by different points of origin will depend on relative supply elasticities and transport costs.

11. These formulations, set within a restrictive framework of "location effects models" lead us to a more general investigation of the problem of more rigorous derivation of transport demand.

A possible approach to the problem is illustrated in the following diagram derived from a monograph by Terziev, Ben-Akiva and Roberts [10].



This diagram can be extended and the framework re-formulated as follows:



The difference between the two approaches is quite basic and illustrative of important decisions which must be made in transport demand modelling which is: should transport and trade (i.e. economic determination of flows of commodities) analyses be integrated in a model *jointly* or treated separately (sequentially)?

A. If transport and trade considerations are to be treated as interdependent, then, the transport demand model must be commodity (or commodity group) specific; demand for transport is treated as a demand from the demand for a commodity produced at a specific location, and there is no demand for an "abstract commodity" from which transport demand can be derived. Thus commodity aggregation must be related primarily to demand characteristics of the commodity in question, and not to its transport characteristics.

B. If, on the other hand, transport and trade considerations are to be treated sequentially[11], then shipment attributes (not necessarily commodity specific) and service attributes (not necessarily mode or carrier specific) determine the modal choice (as well as 'no shipment to market j' option).

The types of questions the two approaches are expected to answer are:

(i) Assuming a level of economic activity (locationally) determined, what is the expected demand for carriage of a given commodity from a specific origin to a specific destination? (formulation A.)

(ii) Assuming changes in transport relative quality price mix, or assuming changes in production or marketing methods which affect shipping/receiving/warehousing[12] pattern, how will the choice of transport mode change?

12. The recent empirical work in the area of freight forecasting is varied both in terms of approaches selected and its scope. As a starting point of this brief review, a study by Brian T. Bayliss is presented [11]. Bayliss starts his review by going back to a standard demand function with the dynamic elements (change over time) taken care of through a distributed lag formulation. However, his review of current work, characteristically enough, relates only marginally to the theoretical demand model. The results given for the freight forecasting model use a simple formulation $T = aP^b$ (where T is traffic volume in ton-miles, P — GNP, a and b constants). The results of estimates made for different countries are reproduced below:[13]

Country	*Period*	*Results*	*R^2*
U.K.	1952-67	$T = 0.66\,P^{0.76}$	0.96
U.S.A.	1947-63	$T = 0.21\,P^{0.62}$	0.99
W. Germany	1950-60	$T = 2.76\,P^{0.70}$	0.94
U.K.	1952-60	$T = 0.54\,P^{0.56}$	0.90
U.K.	1960-67	$T = 0.38\,P^{0.96}$	0.93
U.S.A.	1947-57	$T = 0.28\,P^{0.74}$	0.86
U.S.A.	1956-63	$T = 0.14\,P^{0.51}$	0.63

13. More recently, the Port of New York Authority engaged in econometric forecasting work; the model was based on a two phase estimating procedure: (i) U.S. simple trade model was estimated, then (ii) these results were used to estimate the share of the Port of New York. The model formulation was as follows: [12]

a) Exports (general cargo) - X_{usg}

$$X_{usg} = f(Y_w, P) \quad \text{where } Y_w \text{ - World income}$$
$$P \text{ - Relative prices}$$

$$X_{usg} = 12.84 + 0.489\,Y_w - 26.38$$
$$(R^2 = 0.963;\ DW = 1.38)$$

(b) Imports (general cargo) — M_{usg}

$$M = f(Y_{us}, P) \quad \text{where } Y_{us} \text{ - US income (GNP)}$$
$$P \text{ - Relative prices}$$

$$M_{usg} = -10.4 + 1.79\,Y_{us} - 0.074\,P$$
$$(R^2 = 0.955;\ DW = 1.67)$$

(c) Ports share — Exports

The port's share was assumed to be dependent on commodity mix — i.e. it was assumed (quite reasonably) that specific commodity groups follow a certain stable traffic dispatch pattern — 'trading partner mix' and production distribution of exports ('Domestic Market Effect'). The the functional formulation is:

$$\frac{X_{nyg}}{X_{usg}} = \mathcal{S}\,(S, D, T)$$

where $\frac{X_{nyg}}{X_{usg}}$ is New York share of US exports

C — 'Commodity Effect'
D — 'Domestic Market Effect'
T — 'Trading Partner Effect'

$$\frac{X_{nyg}}{X_{usg}} = -0.035 + 2.312\,C + 0.146\,D + 0.043\,T$$
$$(R^2 = 0.986)$$

A similar method was used to estimate New York's share of U.S. Import Trade, where the independent variables used were income in the port's hinterland (D), 'Commodity Effect' (C) and 'trading partner effect' (T), where Japan/U.S.-Europe exports ratio was used as the measure. The results obtained were

$$S_{nyg} = 0.931 + 0.448\,C + 1.836\,D - 0.108\,T$$
$$(\bar{R}^2 = 0.942)$$

The third phase of that forecasting project related to the estimate of model market shares, relating to penetration of new modes to physical characteristics of the commodities.

The model is described here with some detail for the following reasons: (i) it represents an attempt to link trade and transportation models; (ii) it tuses rather broad aggregates (thus it represents a continuation of the tradition reported by Bayliss); (iii) is moves towards 'transport' estimates by stages; (iv) the approach is really orthodox with no special theoretical underpinnings (in contrast with abstract mode/abstract commodity approach; (v) time series analysis and proxy series are used as appropriate.

14. Another serious line of investigation was to attrack directly the problem of modal split. The possible lines of approach are:

(i) modal split estimates to be obtained as the last phase of transport model building;

(ii) modal split estimates to the based on the changes in production levels of sectors of the economy which are more-or-less linked with specific transport modes;

(iii) the use of demand and supply characteristics ('abstract mode-abstract commodity');

(iv) direct shippers' survey.

Two distinct methodologies relating to shippers' surveys can be identified:

(i) asking the shippers to rank the importance of the factors involved in the choice of carriers (thus leading to abstract mode formulation), and

(ii) direct observation of the choice of the mode selected.

Bayliss offers the following comments on those alternatives:

(i) Asking the shipper to identify and rank factors determining his choice. "This method is in many respects problematic. Firstly, when the performance of two or more carriers is not explicitly compared (as is usually the case) the obtained information relates only to general transport requirements and not on the value of a factor in the choice whether to use one or the other carrier. For example, if speed is an important consideration, but both carriers offer the choice carriers." Secondly, the preparation of lists which would be acceptable to the respondent and yet capture the complexity of different situations is an extremely difficult task. "Thirdly, such inquiries had considered the factors independently and not their simultaneous interaction." (This is also a serious and valid criticism of abstract mode or abstract mode-abstract commodity approaches). "Lastly, there is always a businessman who wants to appear efficient and assigns precise values to factors which before he never took into account." [13]

(ii) Attempts to deduce the model choice from the actual shipments. This method has been attempted in the extensive studies conducted in the U.K. in the late sixties [14].

The analysis has been limited to the processing industries, since in the case of their shipments, there exists the greatest substitutability between the carriers. The businessmen were asked to provide specific waybills (or bills of lading) which *i.a.* contain information on the carrier, type of traffic, weight, destination and rate. This information can be obtained from the records of many firms, but as it was necessary also to ask questions on the so called "special characteristics" of shipments, the waybills had to be complete as at the time of movement and not retrospectively. Questions regarding "special characteristics" relate to the use of containers and special vehicles as well as to the regularity and urgency of shipments. By means of a postcard which the shipper sent at the time of despatch it was possible to obtain information on the damage and speed of delivery and by means of a questionnaire following the inquiry one could obtain data on the lost shipments. An important information not contained in the waybill are the costs which would have been incurred if other transport media were used. Two aspects of this problem can be considered: one can either use the *actual* costs or the *expected* costs of the alternative. In a perfect market system there is no difference between the both approaches, but in an imperfect one, as it exists in reality, the shipper can have either false or no perception of the alternative costs. Since the demand research attempts to obtain the subjective estimate of the shippers which lead to the modal choice, the second method was chosen. The completed waybills were thus returned to the shipper so that the expected costs for every shipment if the alternative mode was used could be given. The measuring of the subjective *vs.* objective factors for the choice of mode also applied to other factors than costs. E.g., the expected transport time and the expected damage or loss and not the actual transport time or loss. While one used sample data of this type, the market was also analysed *ex post.* When the shipper considers the damage as an important factor in his choice of carriers, then he will try to find a carrier who is likely to transport the commodity in question without damage. Hence the individual carriers will obtain business carrying goods which they are likely not to damage and thus the results of different carriers with respect to damages *ex post* will not vary.

In different words, the *ex post* analysis of a situation will indicate the specialization of carriers with respect to different types of traffic, but it will not bring into focus the possibility that these results followed the wishes of the shipper.

In order to overcome these problems, the shipper was asked about his personal assessment of the importance of speed, accessibility, damage and loss in his choice of carriers.

In addition to the factors such as information on the objective shipping conditions and subjective evaluation by the shipper there exist also enterprise factors which have an effect on the choice of carrier. Often the state of transport facilities to which the enterprise has an immediate access, such as own vehicles or vehicles under contract, private railway siding or location on a canal as well as the location and size of the enterprise, exercise an influence on the choice of a transport medium.

Altogether there are three main groups of factors which influence choice of the carrier, namely factors relating to shipment, plant or enterprise characteristics and the subjective evaluation.

A rather different approach to the problem of modal choice was reported by Atsushi Komatsu of Nittu Research Center in Japan [15]. This approach involved the analysis of common characteristics affecting modal choice but grouped by industry. The common factors considered were: (1) location, (2) point of delivery, (3) traffic volume, (4) duration (time) of movements, (5) number of employees, (6) area of plant, (7) dispatching facilities, (e.g. railway sidings), (8) receiving facilities.

Leaving the first approach aside, the problems arising can be summarized as follows:

(a) The use of relatoinships between the producing industry (commodity type, location) and consumption activities (economic determinants of consumption, location), on one hand, and specific transport modes is adequate where such relationships are reasonably stable and either one mode predominates or an inter-model competition pattern is firmly set. Such conditions exist (in general) in bulk commodity production, but not in the more advanced parts of the manufacturing sector.

(b) Modal split models based on the demand and supply characteristics. These have been discussed in the context of the abstract mode. Remarkably, the costs of transport were not included, which may be explained by local difficulty in getting these types of data. This approach attempts to link observable industrial distribution characteristics such as the dispatching and receiving facilities with industry structure information. Properly carried through, this approach may provide a useful elaboration and extension of traffic forecasting based on the changes in production levels.

15. A comprehensive attempt to deal with all the facets of transport demand modelling based — let us add — on superb and comprehensive statistical information, was the model developed by the Netherlands Institute of Transportation [16].

The model developed consists of a number of sub-models:

a) The production and attraction model to determine the incoming and outgoing traffic flows per region and per commodity group.

b) The distribution model to determine the geographical distribution pattern for each commodity group distinguished.

c) The modal split model to determine the volume of the freight transport per transport relation, per commodity group for each mode of transport.

d) The traffic production model to determine the number of traffic movements per transport relation, per commodity group and per mode of transport.

e) The assignment model to determine the future traffic volume in relation to the capacity of the future traffic infrastructure per mode of transport.

. . . the various sub-models do not operate as one simultaneous process but that the determination of the volume of the traffic and transport flows take place interactively [17].

For the details of this work, the reader is referred to the quoted source. The following observations can be made:

(a) The model was based on firm theoretical foundations.

(b) Alternative formulations of estimating techniques have been considered and adopted or rejected on the basis of comprehensive testing.

(c) A superb statistical base both relating to transport industries and production/consumption activities existed.

(d) This excellent base was *further* supplemented by a large scale sample survey of shippers which provided information on individual consignments (time, cost, size, traffic volume, loading and unloading facilities, size of the firm). Based on extensive information collected (and high quality collection system in place) extensive tests on homogeneity of groups of commodities have been made.

It is important to keep in mind the data base advantages which Dutch model builders enjoyed as well as compactness and centralization of the country and the tradition of gevernment-industry-research co-operation. These conditions are rarely duplicated in other environments, which forces the realistic model builders to proceed in a less ambitious manner.

16. At this stage, the Canadian traffic forecasting model can be briefly introduced. The model referred to is the CTC freight demand forecasting model; since extensive descriptions of the model are available only most general methodological considerations need to be noted. At the very earliest stage of the model building, the following desiderata were stated as follows [18].

– Forecasting activity is necessarily a service function - its only aim is to improve decisionmaking. Thus the assessment of the usefulness and adequacy of a program is necessarily a pragmatic one.

– Forecasting may be viewed as a bridge between the *available* quantitative material . . . and forward planning.

– Theoretically a consistent general interdependence model is obviously desirable. In practice, the success of such an approach is made difficult by the demand such an approach curtails for consistent and detailed data . . . data requirements [for a comprehensive model] are likely to exceed the potential - let alone actual - capacity of our statistics collection system.

– For many (most?) purposes, specific sub-models will have to be developed.

Specific problems foreseen in model construction referred not only to data problems, but also to linkages with macroeconomic or regional models and aggregation (disaggregation) problems. Modal split and peak measurement and forecasting issues were noted as the important *further* stages in program development.

The actual model development has indeed proceeded in stages, individual stages were regional trade[14] pattern/traffic by a specific transport mode, and subsequent linking of specific commodity models. Modal split, analysis of the influence of supply conditions on the observable traffic patterns, peak analysis and finer regional disaggregations still remain to be considered. In effect, a more comprehensive approach noted in the previous section has been stretched out and phased over a longer period of time to exploit fully data availability. This approach, adopted by necessity, has had an advantage of permitting "learning by doing".

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[7] Brian V. Martin and Chas. B. Warden, "Transportation Planning in Developing Countries", **Traffic Quarterly,** Vol. 19, 1965, p. 61.

[8] W. Brian Arthur and Geoffrey McNicoll, "Large-Scale Simulation Models in Population and Development: What Use to Planners?", **Population and Development Review,** Vol. 1, 1975, pp. 253-254.

[9] Martin and Warden, **op. cit.,** pp. 65-66.

[10] M. Terziev, M. Ben-Akiva, P. O. Roberts, **Freight Demand Modelling: A Policy Sensitive Approach,** Cambridge, Mass: Massachussetts Institute of Technology, Centre for Transportation Studies, CTS Report 75-6, 1975.

[11] Brian T. Bayliss, **Methodische Probleme von Verkehrsprognosen** [Methodological Problems of Traffic Forecasting], Gottingen: Vandehoeck Ruprecht, 1970. At that time, Bayliss was Professor of Economics, University of Sussex (England), and had been responsible for the major U.K. traffic survey.

[12] J. Gilbert, Nai-Ching Sun, A. Ilan and M. C. Bunamo, "The Foreign Trade Econometric Model", Transportation Research Forum, **Proceedings - Fifteenth Annual Meeting,** vol. XV, No. 1, 1974, pp. 115-124.

[13] Bayliss, **op. cit.** Translation from German text.

[14] B. T. Bayliss and S. L. Edwards, **Transport for Industry,** London: H.M.S.O., 1968 and B. T. Bayliss and S. L. Edwards, **Industrial Demand for Transport,** H.M.S.O., 1970.

[15] "Factors Influencing Freight Mode Choice", College d'Europe and Transportation Research Forum, **Proceedings of the International Conference on Transportation Research,** (Bruges 1973), Oxford, Indiana: R. B. Cross Co., 1974, pp. 599-606.

[16] J. van Es and C. J. Ruijgrok, "Modal Choice in Freight Transport", College d'Europe and Transportation Research Forum, **op. cit.** pp. 585-598.

[17] **ibid.** p. 587.

[18] K. W. Studnicki-Gizbert, "Conceptual Problems in Forecasting Inter-regional Traffic Movements", College d'Europe and Transportation Research Forum, **op. cit.** pp. 580-584. Statements quoted reflect the preliminary thinking on the development and scope of the program.

FOOTNOTES

1. For the sake of clarity we offer the following difinitions:

a) A goal is an ultimate desire of a society to be attained at some given time horizon;

b) an objective represents a short-run preference between alternative states of the economy, and it is expressed in a form of a set of targets to be attained subject to socio-economic constraints. Short-run refers to a period within which resource constraints are absolute and cannot be altered. Casual empiricism suggests any period up to five years;

c) instruments are these policy tools at the government's disposal which it can impose on the system to attain objectives and advance society toward the attainment of its goals. Such tools are (among others) monetary and fiscal policies.

2. Will be termed as the "Document" hereafter.

3. It was Jan Tinbergen who constructed and estimated the first large scale econometric model of the Netherlands (in 1936).

4. The CTC Forecasting Program follows such logic.

5. This section may be omitted without loss of continuity. We think it is desirable to include it in this paper, for it summarizes in a compact way the properties of causality in structural models.

6. This is in addition to the model's internal consistency requirements discussed in preceding paragraphs.

7. CTC stands for Canadian Transport Commission

8. The "natural extension" of this line of analysis, is to trace the macroeconomic effects of transport investments, either in the context of cyclical fluctuations (see J. Beare's article in K. W. Studnicki-Gizbert (ed), **Issues in Canadian Transport Policy** or in the context of long term pressure on the available investment resources.

9. E.g. objectives and capital costs differ between the "public sector" of transport which is responsible for the supply of infrastructure in road, air and water transport and the "private sector".

10. This is a general problem in demand analysis: "Unless strong assumptions are made about supply conditions, the estimation of **demand** equations is impossible; instead the function estimated may be a supply curve or mixture of the two". A. Brown and A. Deaton, "Models of Consumer Behavior", in Royal Economic Society, **Surveys of Applied Economics,** Vol. I, London: Macmillan, 1973, p. 220. Unfortunately, in transport "strong supply assumptions" (prices are fixed by producers; supply is forthcoming at that price) violate some observable "real life" conditions (especially that 'adequate' supply is forthcoming at a price fixed by producers).

11. It should be noted that Terziev et al explicitly noted that "these decisions [production and consumption, distribution and modal split] are often determined jointly and are interdependent in a way that makes a specific sequence arbitrary". **op. cit.** p. 43.

12. There exists a strong relationship of "abstract commodity - model split determination model" and "inventory theory" models of transport demand (see e.g. W. J. Baumol and H. D. Vinod, "An Inventory Theoretic Model of Freight Transport Demand", **Management Science,** vol. 10, 1970. The authors describe their model as an "abstract mode-abstract commodity model" **op. cit.** p. 413). However, not all "abstract commodity" models aimed at the explanation of modal split take inventory theoretic approach.

13. **ibid.**

14. As reflected by production and consumption of major commodities by regions.