THE DETERMINANTS OF MODAL CHOICE IN THE FREIGHT MARKET

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Introduction

Research work recently completed by the Netherlands Institute of Transport has given useful insights into the determinants of modal choice in the freight market. The project used international transport data collected on behalf of the EEC transport Commission in EEC member countries plus Spain. A broad examination of possible explanations of the aggregate shipper behaviour was undertaken. The relevant questions being: there seem to be rigidities in shippers responses; modal advantages seem to be uneven for a single commodity; the explanatory power of absolute variables such as tariff and transport time seems low. All of these translate into perceived impredictability of freight transport markets and low apparent sensitivity to changes in modal characteristics. At the same time, strong modification of modal participation in the transport of commodities, and a trend in the direction of modal specialization observed throughout the world tells us that a mechanism yet to be set forth might very well be at work.

Past research in this field has been impaired by a lack of data of sufficient quality. Moreover, the costs of data gathering have pushed research efforts in the direction of theoretical developments with tests on fairly small data bases and results have not been very encouraging.

The availability of a substantial and consistent body of data covering over two thousand origin-destination pairs in seven countries gave us the opportunity to examine this data in search for structures and explanations of modal choice decisions. This had not been possible heretofore. All important data collection efforts in the past have been oriented to flesh-out an application of a theoretical construct or model which has been assumed, a priori, to be correct. Most of these efforts have had a narrow regional or national focus. As such, they have all been applications of a given view of the problem as opposed to research into what is actually taking place.

In view of the perceived complexity of the problem, the research team was given a very narrow authorization. Work was to be limited to the existing data and associated countries. A decision on extensions to countries outside the sample was to follow this initial stage. The purpose of the project was to test hypotheses and indicate whether this was a worthwhile course of further research. These objectives have been accomplished and a brief description of some of the findings follows.

Main Findings

A modal share function strongly representing the observed data in all cases was found. Several functional forms were tried and in the process some useful insights and confirmation of prior observations were obtained. Before going into them however, we need to emphasize that the

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examination of the data rendered an important result about the structure of the data. The sample of all origin destination pairs for each commodity proved to be too coarse a sample in all cases. It was found that in attempting to predict modal participation or shares in a market, data points arranged themselves in clusters amounting to sub-samples or segments of characteristics quite different from each other. These market segments are dictated by the data and are not the result of prior assumptions. Modal participation has a better chance to be represented accurately when we make an identification of the market segment to which a transport market belongs. Modal share functions of the same general form were found for all segments, for all modes and for all commodities, and the need to discriminate among transport markets even for the same commodity firmly established.

It was also found that some variables had a very small explanatory power as in the case of frequency of service of a given mode. The influence of frequency in modal participation was so small as to make advisable its elimination without a significant loss of information. It was also confirmed that door to door costs and times by themselves had a fairly low explanatory power. This was due to strong cross correlations across modes which actually negated their use as independent variables. It was found that the significant variable in representing modal participation were door to door relative transport prices and relative times door to door to the shipper.

Consignment size showed to be a variable with strong explanatory power, albeit marginally more so than total tonnage per period (year) for a market. The two are strongly correlated, and a decision to use total tonnage instead of consigment size was made. The loss of information entailed made scant difference in the results, and the loss of information is counter-balanced by the easiness and possible accuracy of measurement of total tonage (all modes) between an origin and a destination in any future application of the modal share function.

In the case of modal shares of road transport, it was found that for many commodities and segments, a much stronger representation of the complement of the road share rather than the road share itself was possible. This means, after some algebra, that in the case of many road transport situations the higher the share of road transport the more insensitive it is to changes in transport times, costs or total tonnage.

The use of relative prices and times also allows the capture of the possible effects of technological changes on these variables. Relative variables expressed as ratios also may prove to facilitate the use of the results in totally different settings if and when such work is carried out in the future. This is clearly suggested by the few applications outside the sample performed so far.

Thus, the research strongly identified that shippers select transport modes in such a way as to maximize their individual market prices net of all distribution costs whenever they have a choice of modes to reach potential clients. Transportation costs being a portion of total distribution costs do not explain the mode selection decisions by themselves.

This presentation covers the nature of the work performed, the findings, further insights, the applicability of results with the description of a few examples, and a list of areas of possible further work.

2. The Work Performed

The work performed covered the analysis, interpretation of basic data and synthesis of the modal choice mechanisms at work in a sample of over two thousand (2,000) origin destination pairs associated with international transport in seven EEC countries. The sample covered over one hundred and fifty commodities, which were aggregated to fifty and finally to fourteen groups of related commodities as follows:

- Agricultural Commodities
- Foods
- Fertilizers
- Crude and manufactured minerals
- Ore and metal residues
- Chemical products
- Products of metal industry
- Other agricultural products
- Solid fuels
- Crude petroleum
- Oil products
- Cement, lime
- Other fabricated building materials
- Other articles (mostly finished manufactures)

This data base of 1978 international transport movements had been collected previously by the EEC at great expense and had unique features as to breadth, consistency and degree of detail. The analysis of the data took place in the following stages: segmentation analysis, discriminant analysis, and selection of modal share functions.

2.1 Segmentation Analysis

The size and richness of the sample made possible to address the questions: how homogeneous is the sample of modal shares for each commodity studied? Are there any clusters, any sub-samples which can be identified? Every origin destination pair for every commodity represents one market for transport services, and two descriptions for these markets were selected, distance and annual tonnage transported. The search was for strata or segments in the collection of markets represented by the sample which could still leave us acceptable sample sizes, with each sample showing greater homogeneity than the initial collection of data points. There is nothing new to this concept, e.g.: the manufacturing and auto industries have responded to market stratification into sub-markets for quite some time in their effort to improve marketing strategies. In our case, we are trying to refine our understanding of the modal choices.

The effect of ignoring market segments which may exist for a commodity would be to introduce a perceived randomness, or noise effect in the analysis. Therefore the search for segmentation was a first step akin to a data classification to see if the use of the aggregate sample was justified or not.

It was found indeed that for every commodity, the share of each mode relates to a specific set of segments or subsamples. That is, for agricultural products for instance, the modal share of road transport arranged itself along several segments of markets.
These segments are totally different from those obtained for railways and inland waterways. This was the case for all commodities looked into. The

market segments for a mode and commodity amount to a collectively exhaustive and mutually exclusive subsets of origin-destinations out of the aggregate sample. (The number of subsets fell within 3 and 7 in all cases). Thus, a given origin-destination pair belongs to one and only one segment from the standpoint of a mode and a commodity.

Having found that the treatment of modal shares as dependent variables was responsive to segments of the total market (or demand characteristics of total tonnage and distance if one prefers), the next step was to investigate the relationship between modal (supply) characteristics and the market segmentation. This was done by means of discriminant analysis.

2.2 Discriminant Analysis

The need to relate supply characteristics, such as each mode's door to door time and door to door cost, among others, to the market segmentation already found was the next logical step. The markets from which data has been obtained should show a similar arrangement into segments if looked from the standpoint of modal characteristics serving them if close to an equilibrium. This was an important step for several reasons: first, had this not been the case, the notion of proximity to equilibrium, and the idea that modal supply characteristics alone would enable us to predict modal choice behavior would have suffered; second, the questions left open would have become more complicated such as: are the modal supply variables sufficient to explain modal choices, are there other variables that need to be taken into account?, if sufficient, is the lack of apparent responsiveness due to different weights attached by different shippers to the same variables (even if leading to random utility functions)? - It must be easy to imagine the relief of the research team when there was no need to even attempt to answer any such questions.

The discriminant analysis indicated that using a simple set of supply variables, an overlap with the segmentation analysis of about 70% or better was found (see figs: 1, 2, ref 2). In other words, sample points were arranged along linear functions of modal supply variables in clusters very close to the groupings obtained in the segmentation analysis. These results indicated that modal shares within each segment might be explained by a function to be found of the supply variables selected. Moreover, the results provided some justification for the assumption of near equilibrium between supply and demand for transport services which is necessary to the definition of stable modal share relationships.

2.3 The Selection of Modal Share Functions

The selection of modal share functions attempted to fit a function of modal supply characteristics giving a mode's share in a given market for every market segment for every commodity. Since we have a different segmentation for each mode and commodity, the task was one of evaluating a functional form first, and then applying it to all segments.

There was no prior decision as to which function should be applied or which theoretical construct was best suited. At this point we only knew for sure that if such a function existed we had maximized the chances of finding it. Accordingly, several plausible functions were tested, while realizing that we could conceivably end up with fairly heterogeneous findings, and with difficulties in our effort to synthesize the mechanism at work.

FIG. 1

THE DETERMINANTS OF MODAL CHOICE IN THE FREIGHT TRANSPORT MARKET

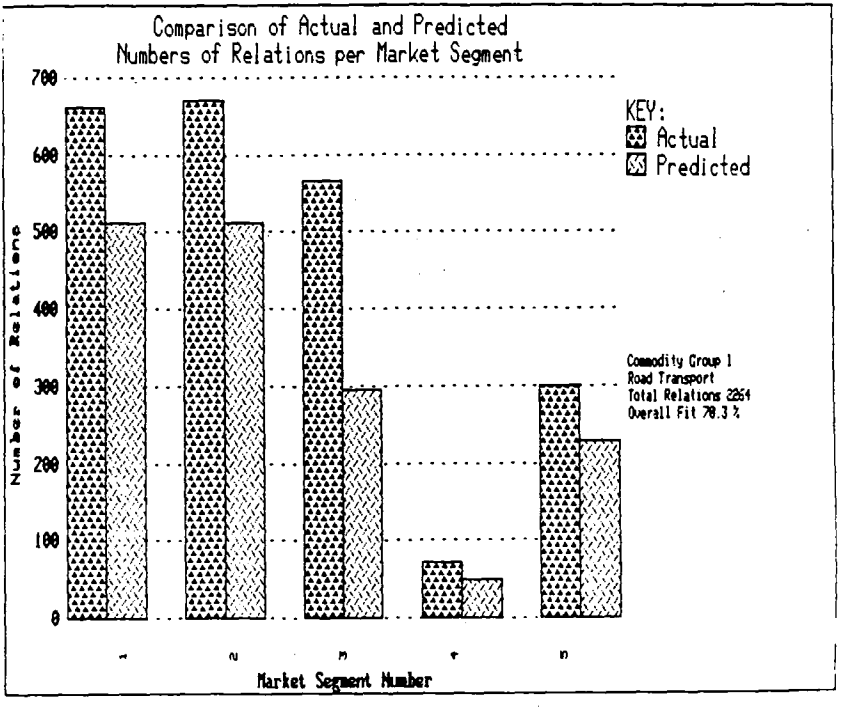


FIG. 2

THE DETERMINANTS OF MODAL CHOICE IN THE FREIGHT TRANSPORT MARKET

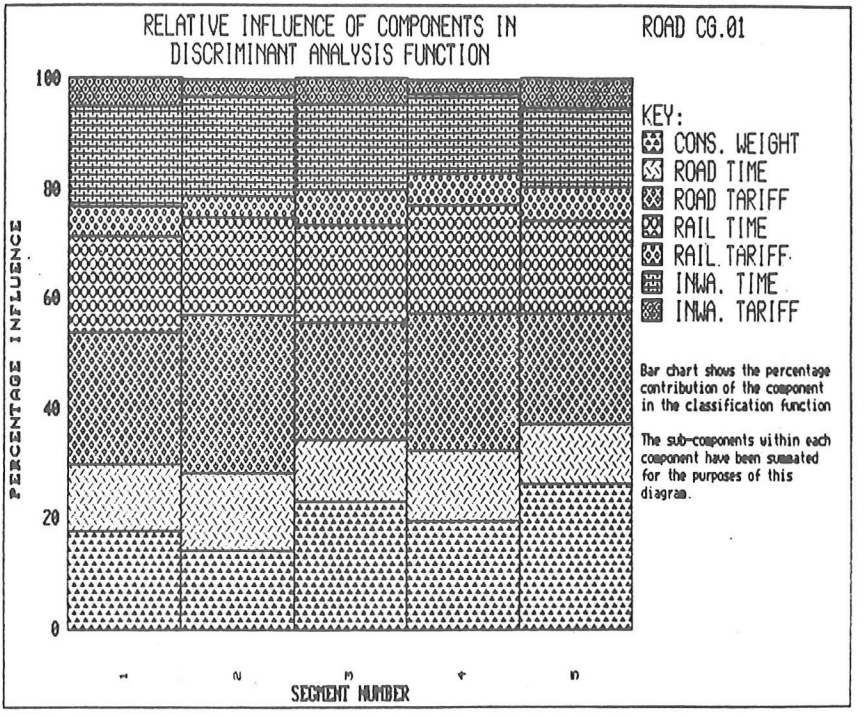


TABLE 1 ROAD RESULTS OF REGRESSION ANALYSIS
COMMODITY GROUP 1 AGRICULTURAL PRODUCTS

SEG NUM	TARIFF RATIO RAIL/ ROAD	TARIFF RATIO ROAD/ INWA.	TIME RATIO RAIL/ ROAD	TIME RATIO ROAD/ INWA.	TOTAL TONNAGE	CONST	R SQUARE
1^	-1.73	1.58	-	0.46	0.48	2.91	0.81
2^	-2.35	-	-	-	-	3.22	0.96
3^	-0.69	2.03	-	-	0.42	0.54	0.33
4^	-2.17	-	-	-	-	2.26	0.96
5^	0.22	-	-	-	-0.28	5.47	0.26

^ Denotes that the complement modal share function was used

The modal share function which best fit the data for all modes, segments and commodities was basically the same. The goodness of fit was extremely good, with the lowest R^2's of about .4, highest in excess of .92 and the bulk of the functions showing R^2's between .70 and .90. The form of the modal share function is the following:

$$S_{m,R} = k\, H_1^{\,x}\, H_2^{\,y}\, C_1^{\,a}\, C_2^{\,b}\, Q_R^{\,z}$$

Where:

$S_{m,R}$ is the share (percentage) of the total transport tonnage in the market (origin-destination relation) R carried by mode m.

H_1, H_2 are variables composed of ratios of modal door to door transport times, with times for mode m in the numerator and times for competing modes "1" and "2" in the denominator.

C_1, C_2 are variables composed of ratios of the modal door to door transport tariffs (these include terminal, collection/distribution and line haul) with tariffs for mode m in the numerator and tariffs for competing modes "1" and "2" in the denominator.

Q_R is the total annual tonnage for the market (origin-destination relation)R

k,a,b,x,y,z, are coefficients determined by the regression procedure.

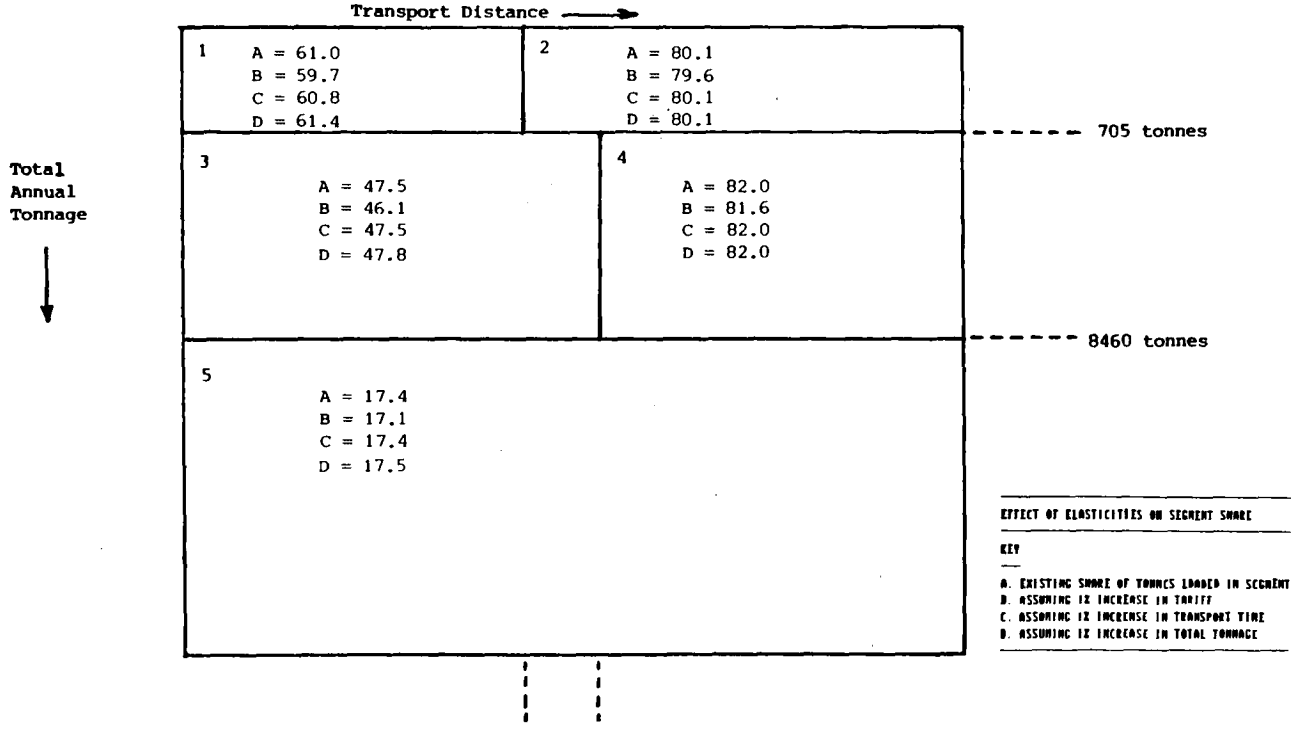
It should be noted that for road transport there were many exceptions. In these segments usually with a high road participation, a better representation of the modal share was obtained by taking the complement of the dependent variable instead (i.e.: $100-S_{m,R}$), i.e: the combined percentage share of the competing modes became the dependent variable. The structure of the function remains the same, and the sign of the coefficents k,a,b,x,y,z reflect the change in dependent variable performed. Some interesting properties which reflect observed transport market behavior follow from this complementary function as we will see below (see table 1, fig. 3, ref. 3).

3. The Findings of the Research

In addition to the existence of market segments for every mode and commodity, and one functional form which successfully explained modal shares in all segments, other equally important findings have been obtained after closer examination of the basic results. They relate to the underlying mechanism at work, the straight forward determination of cross elasticities of demand to changes in modal supply variables, the importance of the annual tonnage variable in the modal share function, the effect of economic growth on aggregate shares for a segment, and the effect of time/tariff variables (akin to technological changes) on the aggregate shares for a segment.

Each one of the themes just mentioned took some analysis and algebra which will not be presented here. We will limit ourselves to give a brief statement on each one of them, so as to alert those readers with specific interests about the areas covered in the forthcoming publications associated with this project.

FIG. 3
ROAD MARKET SEGMENT DIAGRAM FOR COMMODITY GROUP 1



3.1 The Mechanism at Work

The homogenous functional representation of modal shares for all segments and commodities suggested that there might be a formal explanation of mechanism at work. A starting hypothesis is provided by earlier work by Professor W. B. Allen, Wharton School, University of Pennsylvania (ref. 4), who formulated the transport demand for a shipper in terms of the theory of the firm, and had test this formulation on both grain movement and air freight data. It was then found that the individual shipper would select modes and routes to access a market in such a way as to maximize his market price net of all distribution costs, which included transportation. In fact the shipper would incorporate into his production function all distribution costs, and enter markets according to profit maximization criteria.

We have extended this result, incorporating the diversity of situations which arise in looking at aggregate shipper behavior in addressing a given transport market (origin-destination relation) within a segment. It was found there were no assumptions needed beyond the acceptance of the findings of ref. 4 as an initial hypothesis to arrive at the modal share function obtained for all commodities and segments. That is, the modal share functions obtained are consistent with, or happen "as if", every individual shipper had a transport demand function and decision rules as formulated by W.B. Allen in early 1977.

3.2 Cross Elasticities of Demand

The modal share function yields cross elasticities of demand in a fairly straight forward manner. It is worth noting that within a market segment constant elasticities are found. This means that for a given commodity there are as many different sets of constant elasticities as there are market segments.

There is one interesting exception in the case of the complementary modal share function. Here the elasticities are variable within a market segment, and are variable by the application of a factor equal to the ratio of the value of the share of the competing modes over the value of the share of the mode for which the function has been defined. This factor multiplies the same expression of the constant elasticities found for the normal modal share functions. Furthermore, this situation arises in road transport segments with relatively high road market shares for many commodities and a few segments in the case of inland waterways also with high market shares. The case of the complementary modal share function indicates that the higher the participation of a mode to which it applies, the less its modal share responds to changes in supply parameters of its own or of the competing modes. This is something that has been repeatedly observed, and is properly conveyed by the results.

Using the same expression of the modal share function as in section 2.3 above, but expanding ratio variables H_1, H_2, C_1, C_2 as follows:

$$H_1 = \frac{Tm}{T_1}$$
$$H_2 = \frac{Tm}{T_2}$$

T stands for time for modes m,1,2

$$C_1 = \frac{Pm}{P_1}$$
$$C_2 = \frac{Pm}{P_2}$$

P stands for tariff for modes m,1,2

The elasticities (E) of the modal share are the following:

$E_{pm} = a + b$ $\qquad$ $ET_m = x + y$

$E_{p1} = -a$ $\qquad$ $ET_1 = -x$

$E_{p2} = -b$ $\qquad$ $ET_2 = -y$

$E_R = z$

In the case of the complementary functions, the right hand side is multiplied by a factor $\overline{Sm,R}/Sm,R$ to obtain the elasticities, and $\overline{Sm,R} = 100-Sm,R$. (The results for agricultural products are given in Table 2).

3.3 The Effects of Total Annual Tonnage (Q_R)

The variable total annual tonnage for a market (origin-destination relation), or better yet its exponent z has some interesting properties as follows:

i) when $z \frac{100}{Sm,R}$

the mode m captures all increases of freight for that commodity in the market R. Mode m has a dominant position in the market.

ii) when $z = \frac{33}{Sm,R} - 1$

all three competing modes share equally in a increase of annual tonnage transported (case of indifference at the margin)

iii) when $z \lesssim -1$

the mode m is dominated in that market segment and it loses freight for increases in the an nual total tonnage transported.

iv) when $z = 0$

we have a stable modal share for mode m in the market segment for changes in total annual tonnages (the variable Q is not significative).

For the complementary modal share function where applicable, the exponent of the tonnage variable shows similar (symmetric) properties as follows:

TABLE 2

COMMODITY 1 AGRICULTURAL PRODUCTS ROAD TRANSPORT

SUMMARY OF MODAL SHARE AND ELASTICITIES BY VARIABLE
ADJUSTMENT BY COMPETITIVE MODE IN PARENTHESIS (INWA/RAIL)

SEGMENT	1^	2^	3^	4^	5
% SHARE	61.00	80.10	47.50	82.00	17.40
TARIFF	-2.12	-0.58	-3.01	-0.48	-1.94
	(48/52)	(0/100)	(75/25)	(0/100)	(89/11)
TIME	-0.29	-	-	-	-
	(100/0)	-	-	-	-
TONNAGE	-0.31	-	-0.46	-	-0.28

^ DENOTES COMPLEMENTARY FUNCTION WAS USED
COMPLEMENTARY FUNCTION ELASTICITIES HAVE BEEN
CONVERTED TO NORMAL ELASTICITIES

ORIGINAL AND REVISED MODAL SHARES
ASSUMING A 1% INCREASE IN VALUE OF RESPECTIVE VARIABLE

SEGMENT	1	2	3	4	5
% SHARE	61.0	80.1	47.5	82.0	17.4
TARIFF	59.7	79.6	46.1	81.6	17.1
TIME	60.8	80.1	47.5	82.0	17.4
TONNAGE	61.4	80.1	47.8	82.0	17.5

NOTE- The upper table shows the actual modal shares and the tariff, transport time and total tonnage elasticities. The figures in parenthesis show the proportions by which the competing modes adjust to unit changes in the respective variables.

The lower table gives the revised modal shares which are calculated assuming a 1% increase in the value of the respective variable.

i) when $z \leqslant -1$ mode m is dominant

ii) when $z = \dfrac{0.33 - \frac{Sm,R}{100}}{\frac{Sm,R}{100} - 1}$ we have indifference at the margin

iii) when $z \geqslant \dfrac{\frac{Sm,R}{100}}{1 - \frac{Sm,R}{100}}$ mode m is dominated in market R.

iv) when z = 0 a condition of stable modal shares with changes in total transport exists.

3.4 Growth in a Transport Market Segment

The question of the effect of growth in a market segment is of significant interest. The situation is one in which the production and consequent transport of a commodity grows, the origin and destinations or markets served may fall in one or more of the segments already defined, and the question of interest is: what can be said about aggregate shares in each segment now that we can predict shares at the individual market level?

Let us take the case in which all markets expand at the growth same rate (g):

$$\frac{dQR}{QR} = \frac{dQ}{Q} = g$$

and defining: Sm as the aggregate modal there for mode m in a market segment we have that S'm as the new aggregate modal share for the segment after one period of growth:

$$S'm = \frac{Sm\,[1 + g\,(z + 1)]}{1 + g}$$

and for the complementary function:

$$S'm = \frac{Sm\,[(1 + g(z + 1)] - zg}{1 + g}$$

which predicts aggregate modal shares in a market segment for a given growth rate in the output of the sector. The importance of these results is almost impossible to overlook.

3.5 The Effect of Technology Changes

Technological changes in a given mode may change any one of tariff and time or both for a given mode in a market segment. The market segment becomes of interest when a generalized technological change takes place. The effect on aggregate modal shares of these type of changes can be stated using symbols already defined as follows:

i) for door to door tariff changes at the end of one period
$S'm = Sm\,[1 + r\,(a + b)]$
in which r is the rate at which tariffs change

ii) for door to door time changes
$S'm = Sm\ (1 + t\ (x + y))$
in which: t is the rate at which time changes

and for the complementary function:

i) Tariff changes
$S'm = Sm\ (1 + r\ (a + b)) - r\ (a + b)$

ii) Time changes
$S'm = Sm\ (1 + t\ (x + y) - r\ (x + y)$

The above results certainly do not capture everything which may be affected by technological changes within a mode. But to the extent that modal shares are responsive to time and tariff - and there is strong evidence that this is the case - the effect on aggregate modal shares in a segment as a response to technological change will be the one given by the results above. These results are an upper bound to the new modal share since likely responses by competing modes have not been taken into account.

4. Further Insights

The modal share functions developed also are helpful in the evaluation of alternative tariff policies. Cost data to analyze profit maximizing tariffs was not available, and an analysis of how to maximize the rate of improvement in tariff structures was performed instead. It allowed the discussion of the tariff structures of the three competing modes in terms of their approximation to profit maximization. The extent to which maximization of the rate of improvement in profits is proximate to the profit maximizing policy is left out for lack of necessary data.

For example, assuming that revenues exceed costs and, a convex cost function such as:

$$C = A(Q)^2 + BQ + L$$

where Q is the tonnage transported by the transport services firm, C its average costs, and A,B,L are nonnegative coefficients, a relatively simple, non-linear equation gives the change from current tariff to maximize the rate of increase in profits (decrease in deficits) in a given market segment. This result further simplifies when C is a "shallow" function (i.e.: $C_2 \approx C_1$) to the following expression:

$$r_m^o \approx \frac{(a+b)L}{Rm\ (1+a+b)} - 1$$

where: r_m^o is the revenue maximizing increase or decrease in tariffs in mode m;
a, b are already defined in the modal share function; L is the constant in the cost function;
Rm is the unit tariff for mode m.

Some interesting graphs to quickly address situations in which this result applies have been arrived at and are provided with possible cases and fully annotated algebra of the developments in ref. 3.

5. Applicability of the Results and Some Examples

The question of importance to the transportation community is obviously: how applicable are the results obtained, and if so, how easy to apply are they? The second question has been hopefully already answered. In a setting in which shippers make modal decisions, every market or origin destination pair for a given commodity, has as many modal share functions as competing modes. The coefficients of these functions are all that is needed to fully understand the forces and trends at work in that market. The results are certainly easy to apply.

If the modal share functions are applicable outside the sample of original countries, very little is required in terms of "new" data beyond yearly total tonnages for that market (the distance supposedly readily known) to identify the segment and the modal share function one needs to work with. Additional data are the supply characteristics for transport modes in that market which are available or at least maybe collected in relatively straight forward surveys. Obviously, the key to the process at work are the exponents of the modal share functions.

Can we use them outside of the EEC?

Let us keep in mind that individual modal supply variables by themselves have shown low levels of significance, their explanatory power is not particularly high. It is the levels of the transport technology and the resulting modal supply variables which are likely to be different in developing countries. The work performed has found that the relevant variables are relative tariffs and relative times, and significant sensitivity to them has been detected. These dimensionless variables should facilitate the transferability of the modal share functions.

There is still one question left however, how invariant are the boundaries (volume, distance) of the market segments? A definite answer requires additional field work. Nevertheless, there are indications - such as in the modal choice trends found in India showing the same process of modal specialization as in Europe in spite of a much less developed road infrastrucure - to suggest the convenience of testing in the field the validity of the segmentation and modal share functions with a few direct applications. In this way, the need to repeat the collection of information leading to a segmentation study would be established in advance of making such a decision.

Finally, and most importantly, the effects of the use of variables restricted to the 0-1 range has important implications as well as risks which are also the subject of this section. We take the above questions in reverse order.

Analysis of Residuals

The use of bounded variables opens a question as to how well a given origin destination pair in the sample can be represented by the modal share function, in spite of what apparently are very good representations for each segment as indicated by R^2. Near zero residuals difference between observed and estimated modal shares would indicate a near perfect representation for each sample point.

However, segments in which there are numerous origin destination pairs with shares for a mode close to 100% may show a bias towards overestimation of the modal shares for those origin destination (O-D) pairs with lower observed values. Conversely, a situation with many O-D pairs with a mode at or near zero participation will tend to give underestimated modal shares for O-D pairs with significant modal participation.

In order to evaluate the situation, residuals (observed minus estimated value of the modal share) were obtained for all points in the sample and two commodity groups. These groups were Group 7 products of metal industry and Group 9 solid fuels (mostly coal). These groups allowed the examination both semi-finished and primary products. It was found that residuals tended to be greater when there were numerous instances of either a mode having close to a monopoly in an O-D pair or being close to not having much of a participation. However, this was not a necessary condition as indicated by segments with 59% of O-D pairs with close to total dominance which showed small residuals and a distribution around the zero horizontal line.

In summary, instances of overestimation/underestimation of modal shares are possible for dominating modes/dominated modes where numerous cases of extreme dominance are observed in a segment. That is, for high and low estimated shares there is a possibility of over estimation and underestimation respectively for some market segments. The nature of this bias, when observed, is one of over emphasizing an already extreme situation of modal dominance (see ref 5). Subject to this observation, there seems to be an acceptable representation of sample points by the modal share functions obtained.

The possibility of extending the results outside the sample was also tested and a brief discussion of this experience follows.

Application Outside the Sample

The test of the usefulness of the results outside the sample was made for the same commodity groups reviewed in the residual analysis and for two O-D pairs in France. Although the modes in question were included in the original samples, these pairs represent domestic transport and national transport policies somewhat different from those of EEC countries. Thirdly, we can expect from the residual analysis that: (i) for commodity group #7 a close representation of railway shares and an over-evaluation for road and inland waterways shares; (ii) for commodity group #9 we can expect a close representation of rail shares subject to some random variations, an under-estimation of road shares, and a major under-estimation of inland waterways which should have a very small share of the market.

How close were the predictions? How well identified was the evolution of the transport market? The answers were most encouraging.

The O-D pairs considered were Nancy-Paris for metal products (commodity group #7) and Lille-Paris for solid fuels (commodity group #9). The years of observation are 1980 and 1983. Price changes for each O-D pair over the period were estimated using publish data for O-D transport of some commodities for similar distances which led to increases in railway tariffs of 34%, road tariffs of 8% and inland waterways of 29% for the

period. Total tonnage for metal products Nancy to Paris decreased 45% and total tonnage of transport of solid fuels Lille to Paris decreased 3% for the 1980-1983 period. Door to door times indicated no measurable changes in the period.

A direct application of the modal share function allows the computation of changes due to the variations of input data indicated and magnitude of change factor expected, which in turn was applied over the observed shares in 1980 to obtain "predicted" 1983 shares which were in turn compared with observed data after normalization to 100% total sum (as shown in Table 3 below):

Table 3

A. Commodity Group 7: Metal Products

O-D Pair: Nancy -- Paris

Mode	1980 Base Shares %	1980-1983 Change Factor	1983 Shares Est. %	1983 Shares (Observed)
Rail	68.6	.71	44.0	51.3
Road	29.5	.54*	55.7	47.5
Inland Wtwy	1.9	.17	0.3	1.2
TOTAL	100		100	100

* applies to the complement of the road share.

B. Commodity Group 9: Solid Fuels

O-D Pair: Lille -- Paris

Mode	1980 Base Shares	1980-1983 Change Factor	1983 Shares Est. %	1983 Shares (Observed)
Rail	70.2	.57	43.1	50.6
Road	16.4	2.60	45.9	36.5
Inland Wtwy	13.4	.77	11.1	12.9
TOTAL	100		100	100

Note: Sum of modal shares before normalization to 100 was in the 100 $\pm$ 10 range.

The results are self evident, using structural relationships developed for an entirely different sample, published price changes for the transport sector at large and known changes in total transport we can see that:

(i) the direction of significant modal share changes were well predicted for all modes;

(ii) the nature of the deviations between estimated and observed modal shares is consistent with the expectations given by the residual analysis for the original sample with the sole exception of road for commodity #9;

(iii) a major drop in the share of railway transport in a "railway commodity" such as coal was "predicted" within 15% of observed values;

(iv) a substantial realignment between rail and road for metal products in a relatively short period of four years was predicted within 14% and 17% respectively of observed values;

(v) all predictions excepting that of a mode with a minimum expression, were predicted within 25% of observed values; and

(vi) these results were obtained with no recourse to a local transport data base other than the original zone definition, and with the assumption that the coefficients obtained for the EEC represent the effect of technological and price changes to the modes concerned.

Conclusions

Up to this point only global forecasts of modal traffic have shown a certain degree of consistent accuracy. Regrettably, the need to build and maintain fixed installations as well as to make available specialized equipment in a multi-output service industry calls for equally accurate or better forecasts at the individual transport market level. Not having a way to even approach such accuracy has occasionally become a major problem for transport planners and operators alike.

The results indicate that the apparent randomness and upredicability of transport users is more associated to a lack of recognition of the existence of transport segments with totally different characteristics (with over 100% difference in sub-sample means in some instances) than to a lack of rationality on the part of the shippers. Furthermore, efforts to "rationalize" transport by enforcing more "rational" modal participation are bound to generate strong resistances commensurate to the extent in which they tend to force shippers away from profit maximizing behavior.

The results strongly insinuate that if attempted, forced allocation of traffic would generate a disincentive to produce and ship and/or lead to an increase in delivered goods prices either directly or through increased taxation if subsidized tariffs are allowed.

The results fully explain what heretofore had been surprising turn of events such as: the increased truck transport in the US immediately after the fuel price increase of 1973 (the relative prices of road transport decreased while all tariffs did move up); the reluctance of some grain exporters to use rail transport in Brazil (the expected railway share was just not realistic for the market segment under consideration); the difficulty in rolling back the expansion of road transport shares in spite of the existence of "cheaper" transport alternatives. These are not

necessarily cheaper nor sufficient to effect a major change in modal participation since the variable elasticities observed become smaller the higher the participation of road transport in a market.

A useful way of describing modal choice decisions has been arrived at. The next steps correspond to extensions and application of the results to different situations. Some further work will be necessary in this regard. The field testing of the findings does not require massive data collections. Markets, and commodities may be selected according to their relevance in each case and there is no need for national or regional coverage. If validated, such tests will point in the direction of much simpler as well as much improved transport sector work.

The results clearly indicate that pieces of accepted wisdom concerning modal advantages prevalent in countries in the sample are not valid. Since such beliefs have been freely applied throughout the world, there is a strong argument in favor of developing alternative outlooks. The work just completed is a first step in that direction.

6. Future Research

The findings of this research project seem to point out areas of further work beyond the direct application of its results, if additional resources of research and development were to be available.

The following list is a small sample of possible topics, or better yet, lines of work which can be pursued:

- more case studies both in France as well as in other countries;
- developments of segmentation studies in other countries including the EEC;
- development of microcomputer based systems to facilitate the use of the modal share functions;
- extension of the methodology to other transport situations such as intercity passenger services (the EEC Transport Commission has this study under contract already); and
- further analysis of the effect on prediction power of modal dominance over an O-D pair and commodity.

List of References

[1] Weaver T.E., Taborga P.N., Tardieu P.M.F., Ashworth S.A., and van Son K. - Phase I Report "The Market Segmentation Analysis". Joint Study On the Determinants of Modal Choice in the Transport Market. World Bank, The Netherlands Institute of Transport, August 1983.

[2] Weaver T.E., Taborga P.N., Tardieu P.M.F., Ashworth S.A., and van Son K. - Phase 2 Report, "The Development of Modal Share Functions", Joint Study on the Determinants of Modal Choice in the Transport Market. World Bank, The Netherlands Institute of Transport, August 1984.

[3] Weaver T.E., Taborga, P.N., Tardieu P.M.F. and Ashworth S.A. - Final Report. Joint Study on The Determinants of Modal Choice in the Transport Market, World Bank. The Netherlands Institute of Transport, December 1984.

[4] Allen, W. Bruce - "The Demand for Freight Transportation: A Micro Approach", Transportation Research, Vol. II, pp. 9-14, 1977.

[5] Tardieu, P.M.F. - Technical Note: "Residual Analysis and Selective Applications of the Modal Share Functions". Joint Study on the Determinants of Modal Choice in the Transport Market. World Bank, The Netherlands Institute of Transport, March 1986.