ECONOMIC ANALYSIS OF THE DEVELOPMENT OF TRANSPORT DEMAND*

By

K. Kádas

Institute of Transport Engineering and Organization, Technical University, Budapest

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1. The growing significance of planning the trend of demand for transport service performances and its sectoral structure in the management of economic development

Transport is given a greater and greater role in the development of the socialist countries as well, considering that the interregional and even the international division of the macroeconomic reproduction process also becomes stronger and stronger. What is more, the planning of regional development considers its optimization to be one of its main objectives. The socialist countries carefully plan the economic growth and the concomitant structural changes and they plan likewise the development of transport and its sectoral structure, taking into consideration that the planning of transport is based on the expected trend of the transport needs and the demand for the transport service performances in the management and planning of economic development. This demand and its exact and reliable forecasting or determination, as well as its planning, are also of great significance both in passenger and in freight transport. Econometric methods can be very helpful in both these respects.

In passenger transport, great prominence is given to planning this demand by motorization, which unfolds itself just in the socialist countries almost exponentially. Prominence is given to this likewise by growing urbanization and recently even by the almost explosive territorial loosening of large urban settlements. The ever growing tourism and especially the motorized tourism may be ranged among the factors giving prominence to this.

In the transportation of goods, the planning of transportation demand is stressed by the enterprise endeavour of the socialist planned economy to forestall institutionally the expectable seasonal bottle-necks of transportation, as a consequence of the rapid development in the traffic sphere of the macroeconomic reproduction process.

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2. Statisctical-economical analysis of factors determining the development of the demand of transport performances and their effects on demand

2.1. In macroeconomic respect

The statistical analysis of the processes of transport economics shows that the performances of the transportation of goods grow almost at the same rate as the GNP, i.e. somewhat slower in economically developed countries. In the less developed countries the contrary is true, considering that the so-called degree of refinement of the products is at a lower level. In fact transport ships first of all weight and not money value.

The performances of passenger transport grow at a similar rate in public transport as the GNP; on the other hand, the number of locomotions performed by passenger cars grows faster and in the socialist countries, for the time being, even exponentially. Exacter analyses may demonstrate the effect of other determining factors, too. Thus, in the transportation of goods, the territorial division of the macroeconomic reproduction process, the proportion of commodity production (in agriculture), the tariff level, etc.

2.2 In respect of sectors of transport

According to the respective statistical time series, it is an almost general development tendency that the performances of road transport and even more so those of air transport grow considerably faster than the performances of the transportation of goods by rail [1]. In the transportation of goods, for the time being, transportations by pipeline grow the fastest. And the performances of inland navigation grow generally still slower than those of railways. These development tendencies, *trends today already becoming distinct*, are exactly justified by the transport services of the individual transport branches as use values and by *their multi-element vectors*, by their better, more efficient aptitudes for the *multi-element vectors of the respective transport demand* (more efficient, relative to their costs) and by their more favourable effects — ceteris-paribus — from the point of view of the optimization of *the objective functions of the sender*. It is on such a basis that — — despite the environmental harms caused — road transport, then, in passenger transport, the use of the passenger cars and air transport still gains ground; and so does in metropolitan transport the underground rapid-transit railway [2]. These tendencies are also clearly explained by the *better and more efficient approximation of the provided transport services, as a multi-element vector of use values, to the multi-element vector of the respective transport demand and need*, exacter, *by the more efficient role of these services in the traveller's utility function* — ceteris paribus — manifest in its optimization *as an objective function.*

2.3 In a microeconomic respect

The transport demand (D) of the sender enterprises is closely accommodated to the effect of the transportation to be made use of, in connection with the optimization of the objective functions of the enterprise (this may be of course also marginal efficiency, namely the system efficiency of the enterprise), considering that the mentioned *marginal efficiencies, productivities, as shadow prices*, are mostly much higher than the transportation tariffs, that is, the sender receives in general a significant transport "rent", especially in the case of the transportation of high valued goods. These "rents" (r), as the respective econometric analyses show, are important demand-influencing factors, mathematically modelled as: $D = \varphi(r)$.

The situation is similar in many respects to passenger transport, except that here *the objective function of the traveller may be replaced by the function of utility or benefit* in addition to the fact that here the marginal efficiency mentioned is higher not only than the tariff, but often even than the still higher unit costs of transportation. The latter case is common just in public transport.

3. Economic-mathematical and empirical econometric modelling of the development of transport demand as a function of its determining factors

3.1 Macroeconomical modelling of the transport demand

The development of the total goods transportation demand of economy T_r is usually modelled as a function of the GNP, or of the national income N, in the following simple form:

$$T_r = f(N) = C \cdot N^{\varepsilon} \qquad (1)$$

where ε is the growth elasticity of the total goods transportation demand and/or performance, (possibility expressed in ton-km), related to the GNP, or in this case to the national income, presuming that the complementary factors of the growth are ensured undisturbed, parallel to the growth. According to some statistical analyses, ε itself is a function of the magnitude of the per capita national income and so of the degree of economic development, namely, the higher its level in general the smaller is ε [3]. According to our own our econometric analyses, T_r is not only a function of N and GNP, but it closely depends on the territorial division of the macroeconomic reproduction process, which can often be expressed by the average transportation distance as well. It also closely depends — especially if the role of agriculture is significant in the GNP — on the proportion of commodity production, on the degree of product refinement (it is considerably higher in the developed than in the developing countries), on the tariff level, and so on. According to our analysis, denoting these factors by X_i, $(i = 1,\ldots n)$ and the relevant exponents as partial elasticities presumed to be constant, by ε_i, development of T_r (which is in fact of stochastic character) can be modelled rather realistically by the following function as a deterministic aggregated relationship model:

$$T_r = c \cdot \prod_{i=1}^{n} X_i^{\varepsilon_i} \tag{2}$$

where c is an integration constant, involving the multistage integration of the differential equation system

$$\frac{\partial T_r}{T_r} : \frac{\partial X_i}{X_i} = \varepsilon_i \,. \qquad (i = 1, 2 \ldots n)$$

Considering that both the transportation performances T_r and the determining factors X_i, as index series with the same base, are available in the form of time series, model No. (2) in a dynamized form — in the form of an index equation [4] — may have the following shape, [5].:

$$I_{T_r} = a \cdot \prod_{i=1}^{n} I_{X_i}^{\varepsilon_i} \tag{3}$$

where I_{T_r}, I_{X_i} are indices (time series) of the T_r's and X_i's, and a is also an integration constant. It is easy to see that model No. (1) is a special — ceteris paribus — form of No. (2).

The structural parameters a and ε_i — in possession of appropriate statistical data — can be estimated well enough by e.g. regression analysis, taking into account a certain multicollinearity between the X_i's as well [6]. By the way, theoretical econometric considerations have found multiplicative models No. (2) and (3) suitable for the analyses of transport demand.

The specific analysis of econometric model No. (3) yielded, on the basis of a sufficiently long *ex-post* period, satisfactory results. Without transit transportations, the *model may be considered to be verified.*

The application of additive model

$$T_r = \sum_{i=1}^{n} b_i X_i^{\varepsilon_i} \tag{4}$$

is not excluded either, [7], only in this case the calibration of the parameters may already present more difficult theoretical econometric problems. On the one hand, these may present a quite new methodological problem. On the other hand, this model may already include the great transit transportations (from eastern to western countries), too.

A model similar to model No. (3) can be formulated similar to those outlined for passenger transport, especially for public transport. Modelling of the demand of national public transport is complicated by the ever increasing tourist traffic. For instance, the annual number of tourists in Hungary exceeds the population of the country, near by 50%.

In modelling the demand of metropolitan public transport (eventually expressed in number of passengers) the model of the form

$$I_{T_r} = a \cdot \prod_{i=1}^{n} I_{X_i}^{\varepsilon_i}$$

identical to (3) can be well used assuming that the main determining factors are: the number of population in metropolitan area, the territorial division of the traffic processes, the proportion of wage-earners, the level of transport technique, the level of real incomes, the tariff level, etc.

The locomotion performances of passenger-car transport can be modelled in a quite different manner. This question — rather of microeconomic nature — involves from a macroeconomic point of view that the number of motor-cars *follows the logistic development trend in the socialist countries as well*, it is, however, still in its accelerating stage, showing an exponential form. For this very reason, its approximate dynamic model may be in the decades to come:

$$\text{number of passenger cars:} = A \cdot e^{wt} \tag{5}$$

where w is the annual growth rate, t is the notation of calendar time, A is a constant taking into account the initial number of passenger-cars.

3.2 *Modelling of microeconomic transportation and travel demand*

In the transportation of goods, the service demand D_g of the sending enterprise (as an abstract demand) [8] develops according to the effect influencing, improving the optimization of the objective function of its enterprise management,
Thus,

$$D_g = f\ (\text{the effect of } D_g \text{ and its variation influencing the optimization of the objective function of the enterprise}) \tag{6}$$

This effect improving optimization and the efficiency of the enterprise (E)

can be closely expressed by the partial marginal enterprise efficiency of the growth of D_g:

$$\frac{\partial E}{\partial D_g}$$

and by its shadow price, respectively, if E indicates the net revenue of the enterprise in money value. This and the fact that E is little sensitive to the transportation tariffs explain the fact that the partial elasticity of the transportation demand of goods of a high value according to the transportation tariff is small in absolute value, that is, a rigid transportation demand is involved. In the case of goods of low value, the situation is usually just the opposite. At the same time, this explains also the fact that in the case of goods of high value, the sender may often acquire a considerable transport rent.

In the microeconomic analysis of the passenger transport demand (D_p), D_p can be expressed by the total utility or benefit function of the travellers (U) and the individual traveller, or by its expected effect on the optimization of U as an objective function, that is:

$$D_p = F \text{ (The effect of } D_p \text{ and its variation influencing the optimization of } U\text{)} \qquad (7)$$

This influencing effect can be characterized — in a given case — by

$$\frac{\partial U}{\partial D_p},$$

the partial marginal usefulness of D_p. This explains the fact that in D_p, which is of great significance from the point of view of the optimization of U, the tariff level plays a less important role, and the travel demand becomes rigid from the point of view of the tariff variation. In the case of not important travels, the situation is generally the opposite. By the way, according to our econometric analyses of public transport processes, the tariff elasticity of D_p is generally small in absolute value it hardly reaches 0.3. Thus, a rigid travel demand is involved. This is the reason why it cannot be expected even in the case of *zero tariff* that the number of passengers will increase excessively, nor that people will leave their passenger-cars and hurry to travel by public transport facilities, unless the "park and ride" system is generally introduced.

The much higher adaptability of the passenger car for travel needs is the explanation of the fact that its possession is so popular and that it is spreading at such a rapid rate, although in most cases it makes locomotion more expensive especially if the recent oil prices are taken into consideration.

The transport performance and its vector as a use value vector (u.v.), made by passenger car, covers the vector elements of the demand of the performances to a greater extent than in the case of public transport, although the expensiveness (p) of this and the travel tariff, respectively, are lower than the cost of travelling by passenger-car on the other hand, the *efficiency indicator*

$$\frac{u \cdot v}{p} \tag{8}$$

is considerably higher in the case of travelling by passenger-car. This is especially high in the case of recreational travels, primarily in the field of motorized tourism. Consequently, the individual (microeconomic) passenger transport demand, as a demand function D, can be modelled in the following simple form:

$$D = f \cdot \left(\frac{u \cdot v}{p} \right) \tag{9}$$

Since both the $\frac{\partial E}{\partial D}$ and the $\frac{\partial U}{\partial D}$, as well as the $\frac{u \cdot v}{p}$ introduced in the foregoing still involve difficulties for statistical or informational quantification, there are still several difficult obstacles in the field of the econometric investigations, in the research of the microeconomic transport demand.

4. The dynamization of transport demand functions and the forecasting of transport demand by econometric methods

Forecasting the expected transport performances and the transport demand play a great role in the planning of transport because it provides very valuable *ex-ante* information, of course, with a determined probability. Index equation No. (3) in a dynamized form has proven to be very suitable. Thus:

$$I_{T_r}(t) = c \prod_{i=1}^{n} I_{X_i}(t)^{\varepsilon_i} + R \tag{10}$$

where t is time, R is a symbolic stochastic residual term.

Inasmuch as relationship structure No. (3) is valid until the forecasting horizon, it is sufficient to forecast the development of the X_i's and their indices in time and, in possession of the forecast time series X_i, to calculate the time series of T_r with the aid of model No. (10). This is the two-stage forecasting.

The single-stage forecast is the mechanical one carried out on the basis of the extrapolation of the trend.

In the case of three-stage forecasting, structural parameters ε_i and c are also forecast if necessary. In such a case, forecasting on the basis of e.g. model No. (1) is possible.

The four-stage forecasting may involve the variation of mathematical model structures No. (10) and (3). This is rather seldom within the usual planning time horizons (15-year long-range plans), [9]. The macroeconomic forecastings in goods transportation and in urban public transport carried out with the aid of econometric model No. (10) yielded rather good forecasts.

The input-output models can also well be used in the case of forecasts for shorter periods.

Forecasts of the performances of transport branches and of micro-economic demand have been made only sporadically until now because also the econometric concretization of the subsectoral and the microeconomic demand functions has been made only very sporadically. In this respect, several theoretical econometric problems are still to be solved. These have a number of sociological and psychological aspects as well. Besides this, there are many associations with the problems of statistical decision theory and with some more complex questions of probabilistic logic connected with these [10].

5. Economic paradoxical phenomena in connection with the trend of transport demand and their econometric interpretation [11]

In connection with the lasting price rises in recent years, it has been possible to observe an interesting paradoxical phenomenon in metropolitan, generally in local passenger transport.

Namely, in consequence of the constancy of public transport tariffs their magnitude $p_r^{\cdot}$, reduced to the price and income level (the so-called relative tariffs) decreases more and more.

Considering that the individual travel demand is also p_r oriented, its magnitude, even if to a small extent (i.e. $|\varepsilon_p| < 1$) increases year by year, although it is accompanied by price and nominal income rises. This growth of demand is to be regarded as macroeconomically irrational and superfluous in its entirety, a superfluous burden on traffic of limited capacities in rush hours. An even more interesting paradoxical case is that the tariffs and differences between bus and tramway tariffs are also constant, thus the relative magnitude of the tariff difference also decreases year by year. Upon this effect the traffic of bus transport offering a better travel use value increases more rapidly than that of the tramway, while its capacity is more limited.

In periods and on relations with a scarce traffic, the tariff elasticity of the demand of goods transportation and passenger traffic is generally

$|\varepsilon_p| > 1$. Consequently, *tariff reduction* results in a *revenue increase* for transport operation. It results in a profit increase as well if the unit costs of the operation decrease with the increase of the performances more rapidly than, or at least similarly as the tariff levels, which generate a greater and greater demand.

6. The role of econometric models in the planning of transport demand in socialist economies

In the socialist planned economy, the outlined by no means most developed econometric models of transport demand render a great assistance in the planning of transport. They make it possible to forecast numerically and within proper limits of error, the trend of the needs and demands (where there is a transport market) to be expected in the plan period, forming the basis of transport planning, possibly in the form of so-called adaptive forecasts. Thus, in knowledge of, and accommodated to the expected *-ex-ante-* trend of the other factors, in accordance with the existing optimum criteria they may given an optimally preshaped form.

Summary

Growing significance of planning the trend of transport performances. Three-level economic-statistical analysis of factors determining the trend of the demand of transport performances and their effects influencing demand of transport performances.

Economic-mathematical and empirical econometric modelling of the trend of transport demand as a function of its determining factors. The dynamization of transport demand by econometric methods. The forecasting of transport demand by means of these models. Economic paradoxical phenomena in connection with the trend of transport demand and their econometric interpretation.

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* In Hungarian

Prof. Dr. Kálmán KÁDAS H-1521 Budapest.