TRANSPORT
2008
23(4): 330–334

INTRODUCING DECISIVE DEVELOPMENT ORIENTATIONS INTO TRANSPORT MODELLING

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Received 20 February 2008; accepted 3 October 2008

Abstract: To effectuate a consistent methodology for urban planning taking into consideration the viewpoints of land use and transportation, we need to approach the subject and consider complex social and economical aspects. To handle both of the above mentioned urban planning areas, we shall develop models able to pay attention to all of their restrictive factors within temporal properties.

Keywords: urban transportation, urban modelling, dynamic modelling, regulated urban process.

1. Introduction

We have had a chance to study the association of the research-sector and decision making area. While examining several EU projects (Urbanet, Step, Astra), we aim to prepare an adequate planning method in the point of decision makers and local authorities.

Besides, the increase in transport demand has caused severe imbalances in European metropolitan areas, and therefore forces us to pay attention to the interests of users. Congestion, pollution and extensive energy consumption have been identified as the key causes for the deteriorating performance of European transport systems in the Common European Transport Policy.

Against this background, it is vital to stimulate policies – based on a developed useful planning method – that can support sustainable urban development without sacrificing either economic growth or freedom of movement. Sustainable urban policies have to be based on a comprehensive plan and have to involve different sectors and fields of competence including spatial planning, regional and industrial policy, public transport policy and policies concerning individual motorised transport. Restrictions on car use and parking in city centres, road pricing and improvement in public transport are highly relevant measures in metropolitan areas.

Urban pricing, mobility management and a behavioural change of drivers in favour of public transport are the key determinants of improving living conditions in urban areas and reducing traditional problems in the areas such as congestion, pollution, accidents, noise etc.

To effectuate a uniform and consistent methodology for urban planning taking into consideration the viewpoints of land use and transportation, we need to approach the subject and consider complex social and economical aspects. To develop a flexible, consistent and well handleable model based on the existing models of urban planning, we shall emphasize the capital advantages of the hereinafter given models.

The referred publications ensured the basis for our researches. Casey (1955) first used the gravity model expression. The investigations into the common effects of land-use and congestions (Mills 1974; Anas and Xu 1999) can facilitate the application of the progressive European directives in reference with sustainable development. The approaches of the latest dynamic models (Friedrich *et al.* 2000; Peter 2007) can be thought-provoking by developing a dynamic and controllable urban model. Cascetta and Papola (2008) investigated a trip distribution model involving spatial and dominance attributes. Ušpalytė-Vitkūnienė *et al.* (2006) investigated methods and models for public transport network calibration in Vilnius. Tanczos and Torok (2007) studied the linear optimization model of operating transportation efficiency in urban areas. Azemsha (2006) investigated the optimization methods of the rotational latency of the inverse loading of trucks on international routes. Research of Ziari *et al.* (2006) proposes a novel generalization model for selecting characteristic streets in an urban street network. Ziari *et al.* (2007) investigated models for locating stations of public transportation vehicles to improve transit accessibility. Basu and Maitra (2007) applied their

ISSN 1648-4142 print / ISSN 1648-3480 online
www.transport.vgtu.lt
DOI: 10.3846/1648-4142.2008.23.330-334

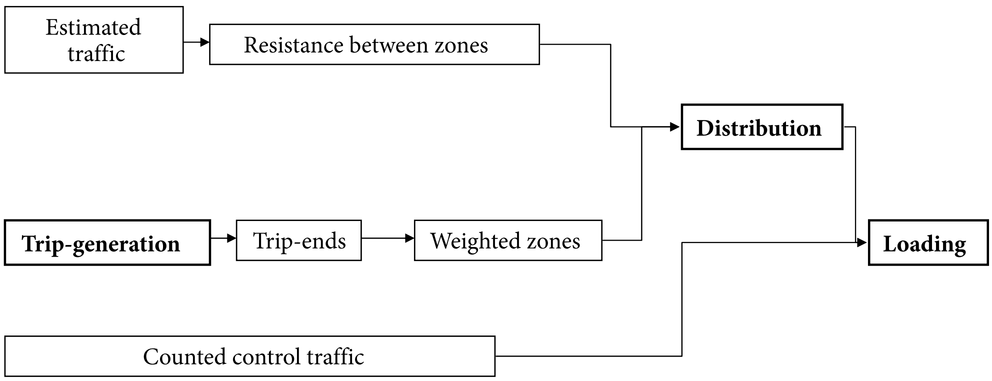

Fig. 1. Flow chart of the traditional transport modelling method

models to use valuing attributes of enhanced traffic information to investigate transport traffic in Kolkata.

The object of this paper is to define the properties of such a dynamic and controllable model on the basis of the newly developed static urban models.

The next part of the article briefly introduces three basic methods of modelling. Considering the above introduced general (social-economic) urban modelling aspects, the main idea of selection was to choose the appropriate models able to provide a well traceable way of transport modelling.

An important point is that the presently applied planning methods generally focus on estimating and comparing the effects of one or two selected measures (e. g. infrastructure investments, land-use or fee-collection possibilities). In contrast to the above mentioned process, the assignment of the best solution from a given set of measures seems to be more effective.

On the basis of this assumption, we would like to investigate the development of optimising methods because at a later stage, we can extend the method not only to describe the behaviour of the components of an individual system (e. g. consumers, firms) but also to estimate and compare the social effects of the changed urban environment (based on the investigated set of measures) and to define the optimal solution from a social point of view.

Hereby, we will have the possibility of controlling the urban environment based on the available set of measures (as a part of the controlling method), the object of the components of the individual system (energy consumption, costs, benefits – as a part of the modelling method) and selected social objectives (e. g. operational efficiency, summed up social costs and social benefits, pollution – as a part of the controlling method).

It has been mentioned that the weight of controlling criteria usually depends on the spatial, social and cultural environment of the actually investigated urban area; hence, in fact, the applicability of such set of weights seems to be relative. Besides, based on the directives of the European Union in reference with sustainable development, we can define a possible hierarchic structure of such a set of weights.

2. Four Step Modelling Method and Possible Development Orientations

Traditional transportation modelling (see Fig. 1) can be partitioned into four distinct segments. The first two steps (trip generation and trip distribution) are usually covered by the gravity model (trip generation, trip distribution – definition the tangible OD matrix on the basis of the given regional data). Consequently, it is possible to cause modal-split (third step) and loading (fourth step).

According to the gravity model, the more weight is ordered to a zone-pair (e. g. depending on population, workplace, school) and the less resistance (e. g. depending on distance, travel-time, travel-cost) can be defined between the given zone-pair, the more traffic will be appeared on the copulative link (Peter 2007).

3. Linear Urban Models and Possible Development Orientations

In the monocentric city models (Mills 1974), the exogenously determined amounts of several goods must be exported outside the urban area. These goods are produced in the city and are used for producing other goods and for final consumption in the urban area. Inputs used for producing every item include the outputs of other goods and various kinds of labor, land and capital. The most important kind of substitution in urban areas is between land and non-land inputs. The ratios between land and non-land inputs determine population and employment densities. Factor substitution is represented in this model by a set of input-output coefficients for buildings of various heights. Goods and services are produced in tall buildings using large capital-output and small land-output ratios. The model works with linear equations and inequalities that can be solved – so the model can be optimized – through a linear programming process (Anas and Xu 1999).

The described model can be developed in a special logistic and policentric approach. The urban area can be divided into several zones. The logistic approach is based on the assumption that all production types of the zones in the city can be described as a process with identifiable quality and quantity of sources (input, e. g. labour, capital, basic commodity) and with identifiable quality and quantity of results (output, e. g. goods and service).

Thus, the zones have their 'exogenously given' production / consumption demand amount / rate with identifiable input and output flows. Thus, we need to estimate the traffic parameter of the input / output flows (input, output amount / carrier unit depending on the mode of carriage).

When applying this method and describing linearly the differing carriage process among the zones we can estimate the given traffic flows of the analysed city.

Besides, we can define the best alternative of a given development or investment from the point of view of the social costs – depending on the result of the traffic estimation module (e. g. the minimum point of the social cost equalities) – or choose the best solution to the possible measure toolkits; moreover, the linear internalization of the zone-value (summation should be given) of the 'exogenously given' variables (production, consumption) can help with defining the optimum structure of the city in an extended way (comparing to a system which exogenously handles the production and consumption) from the point of view of traffic flows.

If we analyse the urban structure in a given time interval with the definition of the time-term of different consumption, service and production types and regulating measures, it is possible to declare an optimal regulation process.

4. General Equilibrium Models and Possible Development Orientations

This type of the model (Anas and Xu 1999) usually has two related goals. The first one can be used for developing a fully closed computable general equilibrium model without predetermined employment locations and with endogenous traffic congestion. The locations of firms and consumers are interdependent in this model, whereas in equilibrium, firms and consumers are dispersed everywhere within the urban area. The second goal of this method is to solve the computable general equilibrium model in order to examine how the imposition of congestion tolls would modify land use patterns in the dispersed urban form (Anas and Kim 1996).

The equilibrium models have a compact social-economical approach that allows us to take into account the decision process of different social levels. Considering as many social interests and utility factors as possible let us maximize the reliability of our model, taking into account that the more social levels are considered the more input data is necessary to supply the model.

On the basis of the so far learnt experiences, the development shall continue in the direction of dynamic modelling. The consideration of temporal changes in decision factors (affecting the traffic structure of the urban area) allows us to estimate the optimal control process of the urban environment in a more reliable way.

5. Dynamic Model

The models, generally used in engineering practice nowadays are static (considering time variables exogenously) and not able to define the system optimum in order to estimate the structure of traffic flows depending on the input dataset (based on the types of behaviour of the model components).

A comparison of the simplest dynamic models with the presently applied static ones shows that perhaps an analysis of the urban area in time will not be able to drive us to as exact estimation results as a complex static model can but we will be able to dynamically investigate the process (see Fig. 2). Hence, the model can be also calibrated and based on the empirical coefficients describing the relations between the input and output time series (besides static input and output dataset).

Another very important part of the dynamically analysed urban process is that after defining the static optimum of the system in a given system state (considering static input and output dataset), we can decide whether it is necessary to influence the process. Having evaluated the static situation, we can choose the adequate regulation type of the available strategic tools. To build the dynamic model, we need to define the structure of the static model that can provide the input data of the dynamic optimization method.

The commute the process that includes route choice, mode choice, other travel parameter choice (velocity, safety gap) and processes from the point of view of the user, short term measures can be applied to control the situation (e. g.: traffic control system). A choice of the transport object (place motivation) is defined as a medium-term process because it depends on the medium or longer-term variables (based on the traditional decision parameters and habits of the population, e. g. changes in the chosen recreation area influences short term decisions as a choice of the commute-route and depends on the long-term decisions as a choice of residence area). These choices usually can be influenced by the tools of mobility management (e. g. education as a choice of a closer but less attractive recreation centre). If we take for granted that we can estimate the new system states resulted by choosing system components, we can assume that we can influence the choices with measures in a way to drive our system's output according to our objectives. Our objectives can be considered during optimizing our criteria set. Fig. 2 shows a possible structure of the set of optimization criteria. The components of the criteria set can be further developed (e. g. economical effectiveness can be disassociated to energy consumption and operation costs; social justice can be disassociated to social costs and pollution; technical feasibility can be disassociated to technical standards and parameters required by regulations in reference to the given measure, e. g. the cost reducing effect of a highway investment is limited and sometimes is less than it was estimated because of the relation between the maximum speed value and the planning geometry of motorways; environmental effects can be disassociated to influence having no direct impact neither on the sociality nor the individuals of the urban area but on the urban environment, e. g. on the inflection of the landscape and on those having a direct effect on the sociality or the individuals, e. g. segregating effect).

The above described optimization criteria presented in Fig. 2 provide inputs to controlling processes (traf-

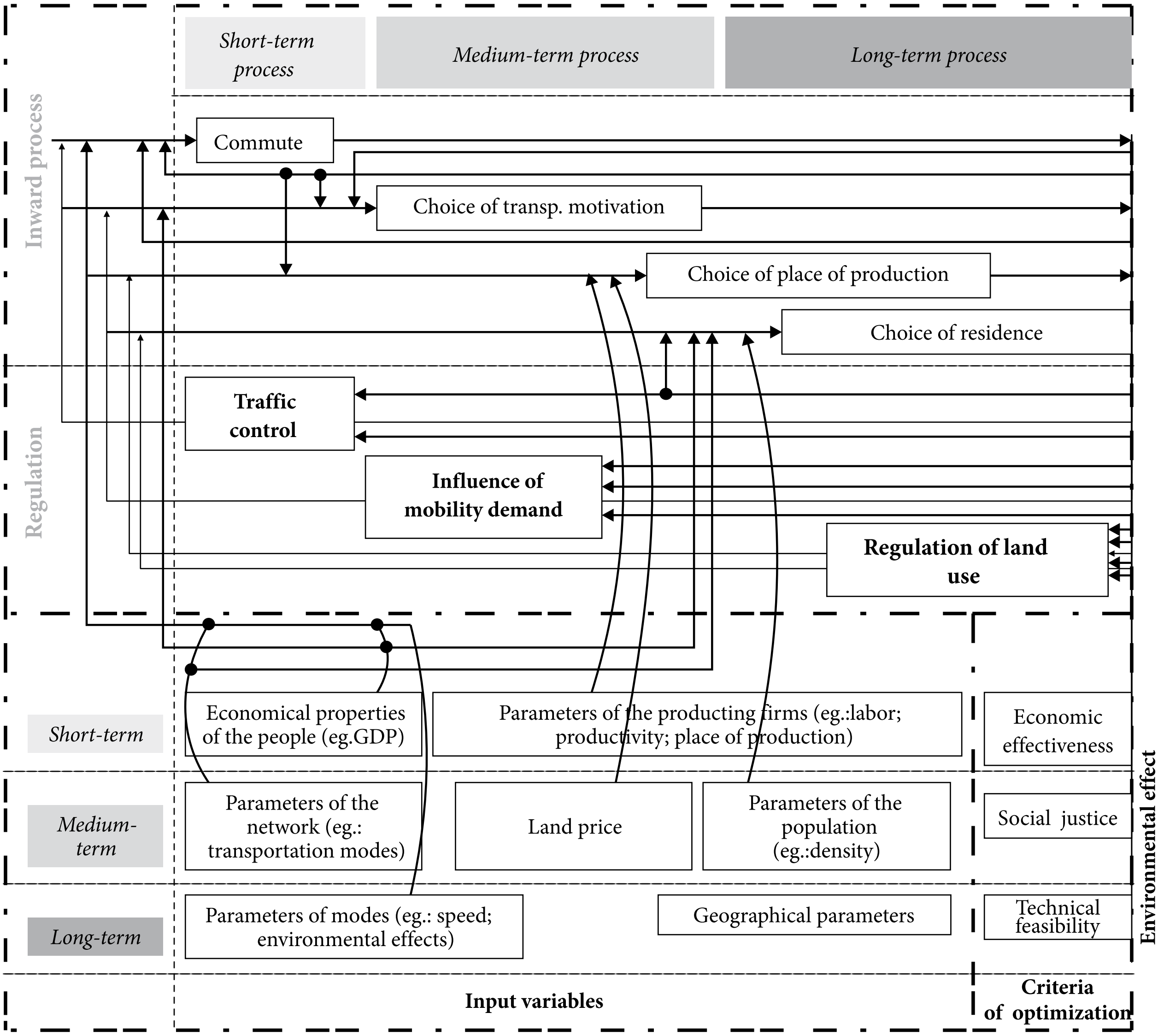

Fig. 2. A possible control model of the urban processes

fic, mobility demand and land use controlling). Hence, we have to build up the decision making processes (commute, transport, place of production and residences) of our model in a way to be able to serve the requirements referring to the input variables of control processes (e. g. the same dimension or order of magnitude; according to Fig. 2, the given transport network determine the choices / route, mode production, living and consuming; choices determine the system state as from a given system state we can move our system closer to the optimum with selecting an adequate measure; in practice, it means that a person will choose a new route because of new infrastructure investment; besides, people can move closer to the developed area, traffic will grow but may result in decreased traffic on parallel roads that may cause lower social-economic costs at urban level).

The long-term urban process includes the long-term decision process of firms and population (e. g. choice referring to the place of producing and living can be affected by land-use regulations – practically, it means that the structure of traffic depends on the traffic flow generated in the zones).

Considering the issue of distributing products to the firms, we can notice that some complex urban modelling static procedures (e. g. spatial computable general equilibrium models) face this problem. In such models, decisions on reference to choosing a place of production are affected by the current production places of the other firms taking into account the effect of the distances of the resource and consumption places (the static model should be based on either general or social equilibrium models, e. g. social rightness can be estimated by recreation zones / activities; see more detailed by Anas and Kim 1996).

With reference to cultural, geographical and economical differences it is difficult to give a weight coefficient to the optimization criteria. Although under the given national and EU regulations we can assume it is possible to define the weights or kinds of hierarchy referring to the criteria set (e. g.: 1 – technical feasibility, 2 – economical effectiveness, 3 – social justice, 4 – environmental effect), it is likely to have more meaning of defining intervals referring to the criteria that can not be exceeded by the output function of the inward processes during the estimation and controlling processes.

6. Conclusions

The presented dynamic approach has several undeniable advantages. Although the dynamic models are more complex than the static ones, even so the following properties can prove us the reason how temporal modelling ensures a higher reliability level of estimation (Koren *et al.* 2006).

Beyond static relations (e. g. counted traffic – estimated traffic) it is possible to consider temporal trends (e. g. verifiable trends towards temporal changes in traffic).

Dynamic models guarantee the possibility of detecting temporally occurring bottlenecks (more detailed temporal analysis allows us to identify peak times).

The regularities of temporal changes in the urban environment provide us the possibility of monitoring the process. The observed controllable process can be ordered toward an optimum state according to the socially accepted aspects.

In conclusion, the efficiency of urban transportation is getting more and more important because of the increase rate of mobility demand. To plan, control and organize urban transportation in the most efficient way, we also need to consider the aspects of land use. To handle both of the above mentioned urban planning areas, we shall develop models able to pay attention to all of their restrictive factors within temporal properties.

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