A Sequential Transport Policy Framework for Sustainable Transport

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Abstract: Transportation is a primary component of contemporary society, producing inevitable benefits, yet giving rise to many negative externalities. Constantly changing transport policies relating to the strategies and goals need to be devised to maximize the benefits and minimize the inconveniences. These policies have considerable amount of economic, social, institutional and environmental impacts. In this paper, a new transport policy framework focusing on sustainable transport is presented. To facilitate the selection of transport projects which really contribute to the achievements of the up-to-date goals from the perspectives of both transport providers and users, an optimization model known from operations research, is also proposed.

Keywords: transport policy, sustainable transport, alternative-fuel modes

1 Introduction

Setting targets is a rather difficult and politically sensitive task. Transportation can predominantly be regarded as a means that implies very different transport policy strategies and transport policy targets being derived from more general targets. We will consider here both scientific and political terms and will discuss target setting for environmental, regional developments and efficiency issues as well. Investment in new transport infrastructure development or reorganizing an old one is very capital-intensive and sometimes may be irreversible in nature. Therefore, such investments should maintain, preserve and extend the achieved quality of life and the utility of the communities, to provide for and improve the safety and security of transportation customers, promote energy conservation, protect the environment and continuously improve effectiveness and efficiency of the transportation system.

A rich collection of transport policy objectives and a wide range of policy instruments with their measures (land use, attitudinal and behavioral, infrastructure, influential and pricing) have been described in [11], with reference to the comprehensive study appeared in [5]. We have also consulted and utilized the works of [6], [8], [9] and [10].

In this paper, first, the main targets of the recent developments of the transport policies of the European Union and Hungary are described. Next, a sequential transport policy framework aiming to ensure a sustainable transport is presented. To select an optimal policy, a multistage dynamic programming model is proposed together with the need of a choice of a multi-criteria decision analysis (MCDA) method.

2 Directions of Transport Policy Developments in the EU and in Hungary

We give a brief summary of the past history of the common European transport policy based on the excellent study of Fleischer [2]. According to this work, such an idea has already originated in the Treaty of Rome. The first official document in this field was published under the title Future Development of a Common Transport Policy (CTP, 1992), also known as the Union White Paper. In this document, the EU laid down the guidelines and the key elements of the Trans-European Networks (TEN), the system of the pan-European transportation corridors (TEN-T). A revised version of the EU transport policy came out in the century turn (White Paper, 2001 [13]), in which, itemized transportation duties were designated in four highlighted areas with a total of 60 measures. Then, in the year 2004, a rethinking of the earlier TEN-T concept has resulted in the extension of this network toward Eastern-Europe in order to enhance competitiveness and achieve better regional transit links. Another change in 2006 diverged strongly from the progressive line taken in earlier White Paper publications and the main direction of EU's transport policy turned to focus on essentially the sustainability questions, like issues of assuring a friendly environment, higher energy efficiency and providing a better balance in regional developments.

Taking into consideration the EU's common transport policy concepts as guiding principles for Hungary, the currently valid strategy over 2003-2015 has been determined in the Hungarian Transport Policy (HTP) [3]. The general objectives, approved by the Parliament were as follows: (*i*) improvement of the quality of life, preservation of health, reduction of regional disparities, increasing safety and protection of the built and natural environment, (*ii*) supporting successful integration into the EU, (*iii*) improvement and extension of connection to the neighboring countries, (*iv*) promotion and implementation of regional development objectives and (*v*) creation the conditions for efficient operation and maintenance by regulated competition. As it marks out from these goals and objectives, they are not defined sharply, their grouping is not entirely coherent, they are not really well-structured and they lack of priority setting [2]. A more focused transport policy description was contained by the documents of the Unified Transport Development Strategy (UTDS) [12] that spans the years 2007-2020. This policy concept prioritizes (*i*) the development of the passenger transport and the transport of goods by improving the international accessibility of the country and its region-centers as well as the regional accessibility (within and between the regions), (*ii*) the development of inter-modal logistic centers (in order to establish efficient distribution functions toward Eastern and South Europe) and the transport infrastructure of urban and sub-urban communities and prevent the highway capacity overload originating from public road vehicles (freight traffic hubs), (*iii*) the development of public transport in cities and their agglomeration (personal traffic hubs), and, finally, (*iv*) the introduction or more environmentally friendly and energy efficient regional and urban transport systems and vehicle usage policies including an increased number of ITS applications. From these settings, we lay down that instead of the earlier planned construction of the TEN-T corridors (No.4: from NW to SE; No.5: from SW to NE; and No.7: Danube and No.10. Highway #6 to Croatia, which has partially accomplished) [7], the major emphasis was shifted to building other motorways and pavement enforcements on the major and the minor roads and thus, paying much larger attention to railroad and waterways developments.

3 A Sequential Transport Policy (STP) Framework for Sustainable Transport

To elaborate robust transport policies for the future bears many challenges. Some of them can be raised as follows. What kind of a balance could be found among engineering, economic, social, institutional and environmental aspects and among the conflicting interests of the different stakeholders? How to reconcile socio-economic and public acceptance of the project due to their unique preferences which are usually different? What extent transport policy objectives, like high level technical quality, sustainability, economic efficiency, preservation of environment, energy conservation, public service, safety etc. could be met as a result of the actions that have been made?

We have developed a new transport policy framework called a *Sequential Transport Policy* (STP) model for *sustainable transport*, aiming to conform to both the EU and the domestic goals and objectives of the same kind. STP enables the prioritization of multiple measures using multi-criteria decision making techniques. This framework sets primary goals that ensure resilience and adaptability in the transport requirements of a given region or a city with special focus on satisfying societal and environmental needs. The model seems to be useful in a global and a local sense as well. STP was planned by keeping in mind to create a powerful tool that promotes sustainable transport. Its structure encompasses four consecutive phases (stages) representing the main goals. As follows, a successful accomplishment of a particular phase is a prerequisite for a start-up of the succeeding phase. This model seems to be useful for governmental departments, transport and infrastructure providers and local authorities when they are faced different alternatives of transport projects and also for transportation users, communities. Now, we describe our STP model in detail.

Stage 1
Policy Goal #1: REFORMULATE DEMAND PATTERNS OF TRANSPORT

Glossary: *Demand* is interpreted as the amount of motorized road transport associated with the amount of street/road/highway use to access a service/activity/household item. *Demand patterns* describe the set of behavioral habits that are characteristic to the users of transport modes.

Objectives: To achieve a change in the current practice of users by reducing their needs for gasoline powered transport, i.e., lessening gasoline powered vehicle km passenger journeys and gasoline powered vehicle km freight distribution per year, traveled to deliver people, goods and services.

Benefits: Reduction of traveling distances; depletion of fossil fuels and thus decreasing harmful air and noise impacts on environment; motivating other transport modes; implement sustainable mobility; inspiring more effective use of existing transportation facilities and resources; to ensure lower motorized mobility, i.e., fewer journeys, shorter distances; switch to public transportation/biking/walking.

Drawbacks: New demand may arise which would neutralize the results by displacing one demand with another.

Tools: Planning and implementing decentralized new global, regional and local commercial/institutional/social infrastructure for communities in order to improve access to goods/services/activities in short distances; expanding the supply and accessibility of favorable traveling destinations; improving pedestrian-oriented design establishments, e.g., short crossings, wide sidewalks, gardens, and existing public transportation infrastructure, e.g. underground entrances, bus stops; subsidizing transit costs for employees and students; e.g. instead of providing 'commute allowances' pay for employees for parking to enjoy free parking opportunities at firms and institutions, give more incentives for car-pool to work, or especially for biking or walking; utilizing flexible time work schedules; applying road pricing tariffs during peak-hours; developing workplace travel plans; introducing time-, distance- and place road pricing for automobile users depending upon when, where and how much they drive; developing ITSs to achieve an effective and wider ranged traveler information service, e.g. about current traffic conditions, apply public notice about congestions and choices for alternate routes; introducing congestion pricing to reduce traffic jams and thus vehicle carbon emissions and heavy gasoline consumption due to idle engines; do not construct new freeways which encourages strongly sub-urban sprawl, instead build sub-urban trains leading to city centers; employing new zoning strategies, i.e. build more compact new neighborhoods with transit and shopping centers possibly within walking distance; letting new apartment houses locate around transit modes and near to corridors.

Measures concerning demand minimization: Achieved distance reductions in journeys with gasoline powered vehicles [passenger km/year], [ton km/year]; investment costs of new regional/local infrastructure [million $], specific measures related to the effect of reduction of gasoline powered vehicle use in urban public transport, e.g. air pollution measures etc.

Stage 2
Policy Goal #2: TRANSITION TO OTHER TRANSPORTATION MODES

Glossary: A *transition* from one transportation mode to another is called a *modal shift*. A *modal share* (*modal split*) represents the percentage of travelers or the number of trips using a particular type of transportation. In freight transportation this is usually measured in mass. *Inter-modal* passenger transport (also called *mixed-mode commuting*) involves using two or more modes of transportation in a journey.

Objectives: The purpose of mixed-mode commuting is to combine the strengths (and offset the weaknesses) of the various transportation options. The major objectives are: to reduce dependence on the automobile as the major mode of current ground transportation and increase the use of public transport and, similarly, a considerable amount of freight delivery happens on highways should transfer to railways and/or waterways.

Benefits: Comparative advantages have many forms, such as reducing pollution of environment, cost savings, since additional congestions would carry economic-cost, capacity extensions, traveling time reduction, extensions of existing flexibility and achieving a higher reliability: depending on what, where and when is being transported the worth of the above factors can significantly vary: the higher the gain is the more incentives are to switch from one mode to another; decreasing bottlenecks would produce large benefits as congestion adds to journey times and makes logistics less predictable which complicates supply chain management routines.

Drawbacks: A significant drop in comparative advantages would contribute to an undesired stopping of this phase, as the new mode gets increasingly crowded, furthermore, opportunity loss may emerge since the previous mode loses traffic, e.g. when some routes have to closed, price cutting must be employed, etc.

Tools: Supporting transitions into modal shift, since these actions take freight off the roads and transfer it to rail and/or to waterway transport; setting modal share targets for transport modes in urban transport (e.g. let 30 % of non-motorized and 30 % public transport), since modal share is an important component in developing sustainable transport within a city or a region; keeping road journeys as short as possible; imposing restrictions on moving freight by road over the weekends; making cars less attractive and in parallel, walking and cycling more attractive in urban transport; enhancing the quality of the waiting facilities at bus stops and rail stations; improving security with the use of ITS devices and reducing vandalism; a general use of electronic information at bus/tram stops and rail/subway stations; building more and larger parking lots at rail/subway stations and also for trucks at the sub-urban areas of the cities; diminishing bus travel times so that to build new bus lanes; reallocating road space to give more priority to pedestrians; creating better integration among modes covering physical interchanges, time-tables, information and ticketing.

Measures to promoting transition: Average speed and/or average time to reach target destinations, traveling convenience and comfort, measures of environmental impacts (emission and noise), proximity to mass transit, frequency of congestion occurrences, changes in scheduling issues (time-table coordination).

Stage 3
Policy Goal #3: IMPROVE TRANSPORT EFFICIENCY

Glossary: *Transport efficiency* is a measure of transportation system performance that shows how well a transportation system and its constituting elements consume resources in a given time period. It is a ratio of the effective (useful) outputs to the total input. Outputs are typically equal to the total supply of transportation services during that period, while inputs are equal to the cost of transportation resources required to produce that output.

Objectives: To improve transportation sustainability and achieve a continuous reduction in transportation costs in order to increase global competitiveness. In other words, to get better outputs from given inputs.

Benefits: Fuel-efficient vehicles require less gas to take a given distance; to burn less gas requires less fuel use (oil), therefore the cost per journey would become lower; fuel-efficient vehicles contribute to reducing global warming, harmful materials' emission, noise impacts and protect public health; for both freight and passenger transportation there could be less cost per journeys; better capacity utilization of the vehicles; land-use improvements.

Drawbacks: There are some challenges concerning efficiency, e.g., the 'rebound' effect which means that improved efficiency will not reduce the need for gasoline powered transport and lead to more frequent travel, which would increase both energy and transportation demand (through the generated traffic or by the induced demand).

Tools: Promoting behavioral changes in the driving habits, e.g., environment- and economic friendly driving style; utilizing longer vehicle combinations to reduce the number of trucks on the roads and highways; permitting use of long vehicles on highways with greater load capacities as opposed to idle running; letting vehicles drive in columns by keeping short distances between them to reduce air drug and improve utilization of the highway network; implementing the so called ‘FreightBus’ concept in urban areas which carries both passengers and goods; introducing the use of purpose-designed load modules which can be transferred to smaller delivery vehicles assigned specifically to urban conditions; extending the use of ITS for helping the drivers to avoid road congestions, places of accidents, etc.

Measures of transport efficiency: Transportation efficiency is a compound term. It implies fuel-efficiency, inter-modal conditions, land-use, vehicle occupancy and a set of trip and routing data. Therefore, traditional measures, like [kWh/tkm] for freight, and [kWh/pkm] for passenger transport are usually not enough to make a thorough analysis. There are a variety of input measures, e.g. volume/mass for materials; labor hour for human resources; navigation prescriptions; terminal operations for services; physical and monetary units for investment capital; weight, power, etc. data for planning and cargo trips, number of vehicle trips, vehicle distances and capacity data for transportation. Similarly, there are a great number of common output measures, e.g., ton-kilometers, passenger-kilometers, special dimension with system boundaries, time dimensions as transit time, peak hours etc., quality of service like speed, reliability, dependability, flexibility, etc. Transport efficiency for the different transportation modes can be expressed as fuel consumption per unit distance per vehicle [l/100 km] or fuel consumption per unit distance per passenger [l/pkm], or fuel consumption per unit distance per unit mass of cargo transported. [l/tkm].

Stage 4

Policy Goal #4: ENHANCE AVAILABILITY AND USE OF RENEWABLE ENERGY POWERED TRANSPORTS

Glossary: *Renewable fuels* are those derived from renewable biomass energy sources in contrast to fossil fuels (petrol and diesel). Renewable energy powered transport includes *alternative-fuel vehicles* including electric, hybrid electric, biomass-fuel, hydrogen, ethanol, methanol, compressed natural gas (CNG), liquefied propane gas (LPG) and other ecologically preferred power sources.

Objectives: To have a sustainable transportation system by improving quality of life for individuals of a society with human and ecosystem health and with efficient operation; offering a choice of transport mode and supporting economy as well by implementing a balanced regional and urban transport. Due to factors, such as environmental concerns, high oil prices, dusty operations, the development of advanced power systems for vehicles must gain one the highest priorities for governments, municipalities, engineering firms, industrial and transportation engineers all around the world.

Benefits: Saving significant amount of costs, since many of these alternative-fuels have high energy efficiency, hence a potential for excellent fuel economy (electric, hybrids, hydrogen); considerable reduction in harmful carbon dioxide, nitrous oxide and particulate matter emissions (electric, ethanol, bio-diesel, hydrogen); less noise impacts on the environment (electric, hydrogen); cost much less than gasoline (CNG, LPG, ethanol, methanol); ensuring environment-friendly operation, providing opportunities to increase choice of transport mode and to fit everyone to meet different life styles; acting as a means of a broad area of engineering and manufacturing developments together with new business opportunities for companies and entrepreneurships and increasing employment especially by inducing need for hiring more highly educated graduates and skilled workers.

Drawbacks: The different types of alternative-fuel vehicles have dissimilar benefits and drawbacks, e.g., purchasing costs of alternative fuel vehicles are very high related to the conventional (diesel and gasoline) vehicles (bio-diesel, electric, hybrid, hydrogen); Huge gas tanks/batteries trunk spaces are needed with less storing capacities of fuel due to their low upper limits (CNG, electric and hydrogen); short cruising distances, long recharging times, frequent need for recharging, low speed (electric); inefficient fuel-economy (ethanol).

Tools: The growing financial support (EU/EBRD/regional) for funding innovation, energy, environmental, societal projects in transportation research and, additionally, the introduction of such new productive technologies with promoting start-ups for the manufacturing of these alternative-fuel vehicles should be fully utilized.

Measures: There are a broad variety of different performance measures, technical, economic, social and environmental related to different engineering characteristics, implementation costs, exhaust fumes emissions (CO_x, NO_x, particulates), energy efficiency measures, then a great number of qualitative indicators for measuring achieved quality of life improvements for the transport users and communities (see also a detailed study of alternative-fuel vehicles in [1]).

Suppose now, that we wish to implement our STP model in practice and assume that the project alternatives of a planned transportation development project are known (e.g to build new infrastructure in an urban area). At this point, the following question can be raised. How can the decision maker(s) select a feasible option from the available set of projects if he/she wants to follow *optimal* *transport policy* through each the four stages. For this purpose, a systematic tool, termed *multistage dynamic programming technique* is proposed as displayed in Figure 2.

In this four-stage model, we denote a point at which a policymaker makes a decision as the *n*th stage, and its corresponding input parameters as the *state*, S_n. A decision itself is governed by some sort of rules, called a *transformation*. At each stage, regarding a given policy goal, the decision maker should make a *decision*.

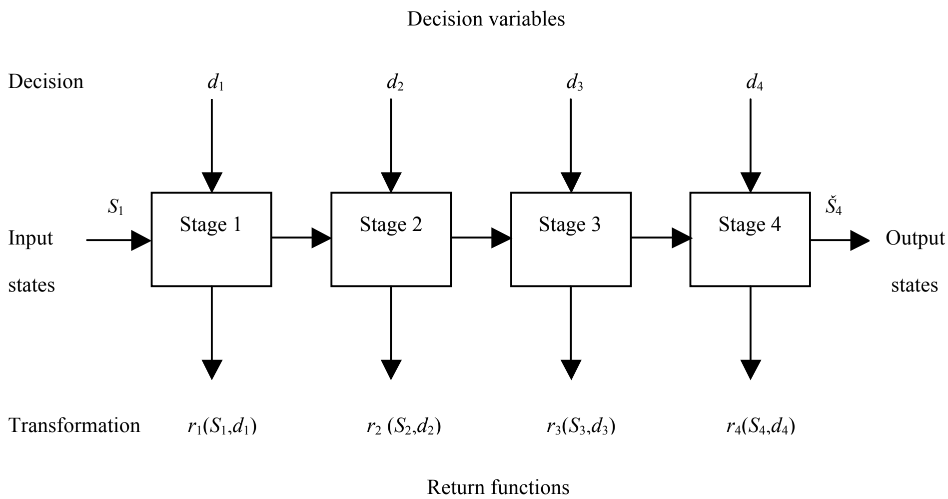

Figure 1

A four-stage dynamic programming approach for the STP model

Every decision has a relative worth. Let these worth (benefit or loss) be represented by a *return function*, $r_n(S_n,d_n)$, since for every set of decision one makes, he/she gets a return on each decision. This return function will, in general, depend on both the state variable S_n, and a decision variable d_n, chosen from the set of feasible decision variables at stage n, $n=1,\ldots,N$. In our case, $N=4$. An optimal decision at stage n would be that decision which yields the most favorable (maximum or minimum) outcome for a given value of the state variable S_n. Each of these stages (decision points) are related by a *transition function*, i.e. $S_n = S_{n-1} \cap d_n$, where the symbol $\cap$ denotes an appropriate mathematical operation of the stage transformation that depends upon the problem under study. The units of S_{n-1}, d_n and S_n must be homogeneous. The designations of these units are determined by the particular problem being solved. Since a state variable is both the output from one stage and an input to another, it is sometimes represented by more than one symbol. Such a dynamic programming approach lands itself best to suit to our transport policy model, since such a multivariable optimization problem can be solved sequentially, one stage at a time. Hence, it is necessary to keep track of all the returns accumulated in this process as one proceeds from stage to stage. Denote by $f_n(S_n,d_n)$ the accumulated total return calculated over the four-stages given a particular state variable. Similarly, denote by $f_n^*(S_n)$ the optimal four-stage total return for a particular input state S_n. That is, a particular value of S_n might give rise to many possible decisions, d_n, among which is a decision, d_n^*, which produces an optimal n-stage total return [$f_n^*(S_n)$]. It is now apparent, that our STP model can be represented as the following optimization problem for determining an *optimal transport policy*, which can be solved by using a *forward recursion*:

$$f_N^*(S_n) = \underset{d_1,d_2,\dots,d_N}{\text{optimize}} \left\{ r_1(d_1,S_1) \otimes r_2(d_2,S_2) \otimes \quad \dots \quad \otimes r_N(d_N,S_N) \right\}, \tag{1}$$

where, in this general expression (1), the symbol ∩ represents any operand dictated within the context of the transport policy problem at hand and, in addition, might change from one stage to the next. As a matter of fact, designing transport projects are usually very complex tasks. Therefore, in many cases, putting them into practice would impose large difficulties for the participants. It appears especially difficult to find the appropriate variables and transform them into homogeneous units. For that, use of proper multi-criteria analysis techniques [4] could be recommended including standardization and normalization of the performance measures, which are often given in different units of measurement, so that they are represented by *utility values*.

Conclusions

It seems that our STP model can lead to effective policy decisions for long term and can ensure a sustainable transport system. However, there is a room for improvement. For example, to build in feedback opportunities and/or ensure some iteration, mainly between stages 2 and 4 appear to be necessary. These are goals for future research. Using STP as a guide, government, local authorities and transport infrastructure providers enable to formulate reliable transport policies and strategies. Communities and transport users can also benefit by gaining higher quality services and activities accessible closer to their home, achieving an improvement of air quality, experiencing lesser congestion and noise effects, and enjoying some further advantages, e.g., a safer and more convenient traveling.

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