INPUT-OUTPUT BASED TRANSPORT SYSTEM MODEL: REFLECTIONS FROM THE FINNISH EXPERIENCE

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Abstract

This paper describes the input-output based transport system for Finland. New innovation of the system is to incorporate the passenger transport into the input-output data framework, in addition to more traditional freight transport analysis. The OPTILI model utilises the 1995 input-output data as the starting point. Regional input-output data was used to create three regions, which represented Finland disaggregated to growth, steady-state and stagnating regions. Within these regions, a further separation into urban, semi-urban and rural areas was made to illustrate impacts on different road classes, as well as on other transport modes. Input-output data was linked to actual traffic flow data using the information on the private consumption on traffic at the 3-region level. Traffic is calculated as travelled mileage (kms). Different modes are calculated separately. The change in traffic volume (mileage) is converted to new volumes by the percentage change in areas, modes, traffic and network classes. The software application allows users to specify the impacts of new transport initiatives and to create alternative scenarios of the future state of transport system and economy. Results from model runs show that scenarios create more significant changes in transport volumes, economic output and employment than transport initiatives, mainly because the initiatives tend to be small in the national or even regional scale, compared to scenarios.

Keywords: Input-output tables; Transport system model; Transport initiatives; Scenarios
Topic Area: B7 Input-Output System and Transpotation

1 Introduction

Man has been constantly on the move. Historically, moments such as the inventing of wheel or the first ever aeroplane both have meant new opportunities and challenges for movement of people and goods. Perhaps of even greater interest to the current generation of research is the day-to-day movement of people and goods: why and where do these move? What is controlling the flows? What will the future of transport look like?

Obviously, the list is endless and with strong caution one should note that there is likely to be no single project that could satisfy all the needs in terms of describing the system in full, for one reason because it is not a static one but a dynamic process. Keeping this in mind, one should establish some sort of approximation of causality in the transport system, what keeps the wheels turning? Here we adopt a simplistic, yet one might argue a realistic view of the world: Money makes the world go around. This is not the first exercise to link input-output data to transport data, but unlikely many of the earlier studies this study benefits from the availability of relatively high quality data on which the model is constructed.

In 2001 and 2002 VTT Building and Transport carried out a significant modelling exercise in creating a transport system model based on consistent input-output setting and regionalised travel data. The results of this project are reported in this paper, presenting the technical solutions of the model and the key conclusions from the exercise. We focus on the use of input-output data rather than the data on transport flows in this paper to show the usefulness of the input-output as a basis for a transport model.

This is not a unique attempt to construct a major transport system model in terms of coverage and level of detail. Recent reviews of various types of freight transport models can be found in Cambridge Systematics (1997), Regan and Garrido (2000), Pendyala and Shankar (2000), Chapters 32-34 (by Friesz, D'Este and De Jong respectively) in the handbook edited by Hensher and Button (2000), EXPEDITE (2000) and Willumsen (2001). As part of the SPOTLIGHTS project for DGTREN of the European Commission, a European Model Directory (MDir) has been established, which contains information on 222 transport models in Europe (some double counting has occurred). Sixty-five of those models are freight transport models and 29 are joint passenger and freight transport models (Burgess, 2001)

This paper is organised as follows. In Chapter 2, we present the basic features of the OPTILI model to give the reader an idea of how it is constructed and how it can be used. In Chapter 3 we talk about different ways to utilise the information within OPTILI model, basically using scenarios and transport initiatives as tools to project future developments in the passenger transport. In Chapter 4 we summarise some of the findings and in Chapter 5 some conclusions and recommendations for future work are given.

2 OPTILI-the Finnish model

2.1 Background

The name of the model OPTILI comes from a Finnish abbreviation for Optimal Transport System (**OPTI**maalinen **LI**ikennejärjestelmä). By its ideological background OPTILI is a forecasting tool, aimed to quantify future policies and initiatives in the transport sector. More precisely, OPTILI is not only about transport policies but it can be also used to take into account broader economic policy framework, which will influence transport sector. This is particularly relevant when we consider policies that effect energy prices or other inputs used in the transport sector.

VTT Building and Transport received financial support for the Finnish Ministry for Transport and Telecommunications for the construction of the OPTILI-model. According to the Ministry, the aim was to construct a tool to use in the scenarios of future transport sector developments, both in terms of transport volume and investments. The additional aim was to provide a useful link between transport data and the surrounding economy, to see how different policies interact.

2.2 Basic data

Statistics Finland, the national authority responsible for collecting most part of Finland's national statistics, has also compiled a set of regional input-output tables, according to the NUTS3 category of the EU system of regions. The base year for these input-output tables is 1995, and the tables have two versions, with the more detailed one containing 37 industries and the more aggregate one containing eight industries. This study utilised the eight industries' division, which is more appropriate for the needs of the transport model exercise. The industries in input-output table are:

Agriculture, forestry and fishing
Manufacturing
Energy
Construction
Trade
Transport, storage and telecommunications

Commercial services
Other services

In addition to the input-output data we also use national data of travel patterns and of mode splits to quantify changes in travel patterns and modes. This data is linked to input-output data using sectoral employment as a key to link household expenditures with travel patterns. As we were able to quantify the policies and their sectoral output effect, we could use this data through employment multipliers to generate changes in employment and then to calculate corresponding changes in trips. We realised that some trips were left out of this approach, most notably business travel, but using the data on travel patterns we were able to correct the data from input-output model to have additional element of trips, which were excluded from input-output tables.

Other linkages were also considered, namely the use of household expenditure data per sectoral output. This approach was not considered too different from the use of employment data, so it was decided that there would not be additional gains from using the household income as a link.

2.3 Data modifications

The biggest challenge in data modification was to integrate the 20 Provinces used in the basic regional input-output data into 3 different types of regions: Growth areas (Southern Finland and Oulu region in the North West), stable regions (Mid Finland) and stagnating regions (Northern and Eastern part of Finland). Within these regions, a further disaggregation was made with respect to municipality type, using a classification into urban, semi-urban and rural regions. This regional classification follows Sirkiä et al. (2000), in assessing the regional dynamics. This is also useful for the analytical work as this gives us opportunities to test the regional impacts of policies.

This further disaggregation led to a system of a total of 8 regions, as the stagnating part of Finland was divided into two types of regions only, namely the urban and rural regions. The third regional zone itself is relatively sparsely populated so there was no need to include an intermediate type of settlement as the region hardly has any semi-urban settlements. Each Finnish municipality was classified into one of the types, so that we were able to assign each community into one of the eight regions. Finally, to arrive to regionalised GDP using the 8-region-division, we have used the population data from municipalities to derive the GDP figures from the Province level data. Thus, in OPTILI we will be able to create scenarios, which will take into consideration both interregional and intra-regional effects.

However, the work was limited to as little changes as possible to the original data. We wanted to ensure that for policy-modellers the understanding of the model and possibilities to return to original source data were possible. This was also done in the interest of ability to update the data in the future, when new input-output and travel data become available.

3 OPTILI as a tool for policy modelling

3.1 Policy scenarios in the OPTILI model

The basic method of analyses in OPTILI is simple. Since we have sectoral employment data for sectors of production, we are using the number of employed people by sector and employment multipliers to provide the link between national economy and the corresponding transport flows. This means that we assume a relation between each industry and the corresponding employment to tell us the current situation of how the use of transport system is composed. By changing something in the industries or in the employment, using the scenarios discussed below, we actually can change the outcome of the use of the transport system as well as on the other variables.

Within OPTILI, we can carry out a number of economic measures studies, which cover a broad range of issues. We can address the following scenarios for future developments:

Population changes

Economic growth

Relative changes between industries

Changes in input prices

Population changes refer to increases in total population of Finland or shifts between different regions. These changes will change both output by region and movement of people within the region. Population changes are dealt with using population changes to change the level of production so that both regions are affected by the change (decrease in origin region creates increase in the destination region). Although the inter-regional movement of people is based on the assumption that the total population change is equal to zero, the corresponding change in economic activity and related transport demand does not necessarily equal zero. This is because the regions have different use of labour input and even between industries. Also, changes between industries will lead to different use of transport system, which also creates different impacts.

The other possible change in population is related to migration to and from Finland. This scenario is different from the previous one because it actually changes the labour force, but because we are able to use the employment multipliers to link population changes with changes in production the treatment is not too different from the inter-regional migration.

Economic growth scenarios include strong economic growth, stagnation and globalisation among others. Changes are reproduces as vectors, which include data on the assumed changes in the economy. Using the vector to reproduce the sectoral output through the input-output inverse matrix will give us the corresponding change. We assume investment to be exogenous, which means that they will bring additional funding to Finnish economy. Examples of such sources of funding include privatisation of state-owned or controlled enterprises and EU funding through structural funds or special projects. To make the investments as concrete as possible, we target the particular industries where the investments are likely to take place in the input-output data. As an example, investments with significant construction component also utilise other sectors like manufacturing and services. Whilst we assume that the Finnish economy will grow over time it is also possible to create scenarios of economic stagnation.

Relative changes between industries are a complex process and we have started from the assumption that we will not change the dynamics of the underlying input-output table to assess the changes. We allow, however, the user of OPTILI to change the sectoral production in OPTILI model within certain interval to test how changes in sectoral output will change the national economy and transport system use in Finland. Changes in industries may include a shift in the agriculture to organic farming or a significant expansion of the electronics manufacturing. Again these changes will have impact on the use of the transport system as people shift between regions and industries.

Changes in input prices include two different inputs for production: energy and machinery. Changes in these two input types are Finland-wide, but they have different regional impacts. Both energy and machinery data were available from the more detailed input-output tables. Changes in the input prices are carried out through the industries, which are responsible for producing these inputs. In other words, we can also use the data on the inputs by each sector, as each sector has different demand for these inputs. To be able to do this, we have constructed a vector for both inputs, which we can change to assess the impact of change on the sectors of production and, using this link, on the transport demand of each sector.

Because we are able to trace the changes in the economy through the input-output tables, two different ways of changing the future conditions were established. First, the operator of OPTILI can change certain variables that describe the future in 2040. These variables include employment (by sector), role of various sectors and demand changes that further change the role of sectors. Second, there are certain transport system operations, which will have an impact on travel behaviour, most notably improvements in various parts of transport system

3.2 Transport initiatives in the OPTILI mode

We have divided transport initiatives in OPTILI into five categories:

Infrastructure investments
Maintenance
Pricing
Service level
Other initiatives

Infrastructure investments are mainly investment targeted to transport sector, but they also have in some case links to other industries and construction. When investments are vehicles or other capital goods, they are considered investments in the manufacturing sector. We also have to consider the possibility of some of the investments going abroad as some equipment is frequently purchased from abroad (trains in particular). In this case the investments will not show in the Finnish national economy. Similarly, if there is assumption that some of the investments are outsourced to other industries the specified initiatives in OPTILI takes this into account.

Maintenance covers various costs of maintaining transport system, both in summer and winter conditions. For road transport particularly winter maintenance and repair work are essential. Like investments, maintenance is considered as an investment to the sector, which has an impact on the transport sector output and this can be further translated to output changes in other sectors as well as to changes in employment.

Pricing initiatives have impacts on demand for transport services in other sectors and they will also affect the employment. Like in the scenario building, impacts of pricing are likely to take place in a number of industries instead of transport alone. Pricing measures can be partial, targeted to special sections (passenger or freight transport, specific mode etc.) or they can be levied overall the sector (emission charges, congestion charges etc.). Also, indirect pricing initiatives such as energy pricing will affect

Service level initiatives focus on transport but they also have links to other sector, such as construction. This group of measures is particularly challenging as often qualitative aspects are included as well to the service level provision.

Other initiatives are a class of initiatives that did not fall into any of the specified categories. This group includes also initiatives on other industries (energy, services and construction), which may have impacts on the transport sector. These measures are not of great economic significance, because they are relatively small and usually take place only once. Unless the measures focus on fixing a specific problem in the transport system, such as a bottleneck, they are not likely to have significant effect on the transport volume.

3.3 User interface

One critical area for constructing a useful transport system model is the user interface. A model, such as this scenario and forecasting model, can be both technically sound and detailed enough, but without a user-friendly interface it can hardly gain any success. Part of the OPTILI-design was to create an interface that would be self-explanatory and rich in detail, both regarding users' ability to design scenarios and the display of results. Figure 1 shows the main menu of OPTILI and some of the sub-menus.

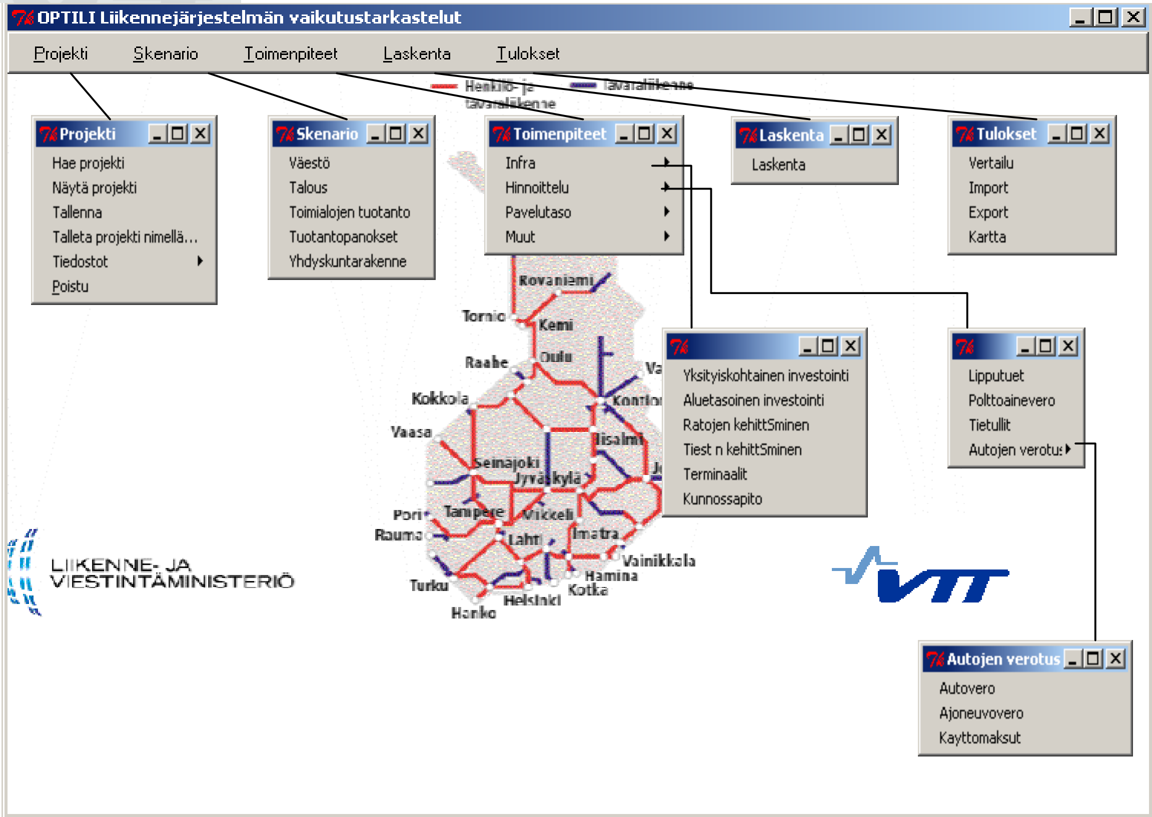

Figure 1. OPTILI main menu and selection of sub-menus.

The user interface consists of three parts. First, the user can choose a scenario of future state-of-the-art, which can be saved to use in multiple analyses or created for each exercise separately. In creating scenarios the user can choose a number of factors he or she believes will shape the future between now and the future state. For scenarios, restrictions on the magnitude have been set to permit experiments that would not be possible in the real life and, thus, to keep the model valid for the original purposes. We have allowed great flexibility even in the restrictions as we are projecting up to 2040 and even significant changes can take place.

Based on the scenario created, the user can test impacts of various policies, described in the previous section. Again, like in the case of scenarios the user will be able to decide on the size of the initiatives, given similar constraints for magnitude. As an example, to assume that Finland would invest 100 billion euros to railway network is not a feasible assumption, so we have limited the size to more realistic levels.

4 Summary

OPTILI-model has been capable of carrying out a number of important features. First, it provides a link between passenger transport and the households, by linking the data of transport flows with household expenditure data. Second, it provides us a new way of thinking about the role of transport in different parts of Finland. This is an important feature of the model, as it allows us to regionalize policies and investments, unlike when using a national level aggregation in the model.

When the model was constructed, a number of alternatives were available for solving the linkages and quantifying the scenarios and initiatives. Where possible, the user has been given full information on the underlying assumptions (Nokkala 2001 describes the use of input-output data), so that users will be able to trace back the assumptions on which the outputs of the model are based on.

OPTILI as a tool of analyses has been made user-friendly and as informative as possible. With the use of input-output data we can also give the user data on employment and GDP effects of scenarios and initiatives, which is more than the normal output of a transport model. This is also a way to promote the use of OPTILI among the policy-makers, as they will be able to analyse even the regional impacts of policies, possibly in the interest of their own regional development, apart from the transport sector targets.

5 Conclusion

This paper has focused on the methodology used in the OPTILI project to analyse changes in the economy on the transport system. We have reviewed some earlier modelling work, the foundations of OPTILI model and how scenarios and measures can be implemented in the model. Based on the current knowledge of OPTILI, we feel the model can capture future changes in transport policy and expenditure. However, for this to happen certain assumptions need to be made. First, the transport system will not change significantly by 2040 for any reasons (WWIII, running out of oil, space travel etc.). Second, changes in the economy do not alter the basic economic structures of the study region beyond the current input-output model. As described earlier, the OPTILI system does allow room for changes, yet everything will be based on the 1995 economy. Third, most of the work is based on ‘business as usual’ approach, where we do except policy changes, which are predictable. In this sense, the views of the Finnish Ministry of Transport and Communications, as well as the European Unions White Paper on Transport are of great help in defining what is feasible and what is not.

This paper has highlighted some of the issues that have been raised and, at least partially, solved in the process of construction a transport system model based on input-output framework. Overall conclusion has been that we have been satisfied with the way the use of input-output data connects the model with the economic activity of the Finnish regions.

Results obtained can have some methodology-related restrictions, which come from two features of the OPTILI-model:

Input-output framework is static, which means that results we present do not tell us anything about the adjustment mechanisms within the national economy, including for instance price adjustments.

Because we are using an eight-region model based on mechanical calculus, we have leave room for error within the three bigger regions. Mechanical division was done using the number of employed people, because this makes it possible to assume constant productivity in each industry.

Where OPTILI-model is useful is its ability to tell us about the regional impacts of national policies, even outside the transport sector. We can study tax and employment policies and EU regional policies in the context of the transport sector to assess the overall policy framework

Some of the immediate recommendations for future work have already been realised. In December 2003 work has commenced on another transport system model, FRISBEE, which also will utilise the input-output data as a basis for the transport model. This model will differ from OPTILI in two respects: First, it will link commodity flow data with regional input-output data using relationships between sectors of production and commodities produced. Second, the FRISBEE will move from NUTS 3 regions to NUTS 4 corresponding smaller regionalised economic units. This is a somewhat similar disaggregation exercise to the one carried out in OPTILI when 8-regions were constructed. Another dimension that is also possible is to combine other Nordic transport models with

OPTILI and FRISBEE frameworks to produce a Nordic transport system model. Some developments in this direction have taken place, but at this point no system has evolved.

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