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Summary:

RETRO/IMREL

A model for transport and land use planning in the greater Oslo area - version 1.0

I. Background

Urban development changes the demand of land for residential or industrial purposes and the requirements for transport supply. New transport infrastructure or modification of the existing transport infrastructure is part of overall planning of land use changes both in urban and rural areas. The close relationship between land use and transport demand implies that we can benefit by the integration of transport- and land use planning.

City planners and politicians may use a number of instruments in planning strategies to affect the developments, where the strategies can be more or less sustainable ways of maximisation of economic efficiency. Instruments that can be used as part of strategies to achieve goals for efficiency and sustainability includes regulation of areas for new purposes, establishment of new transport infrastructure or modification of the existing transport infrastructure. Available instruments in official land use and transport planning also includes movement of workplaces in government and municipalities and pricing instruments for planning purposes (e.g. road pricing or property taxes).

II. Objective

This report describes how the Regional transport model for Oslo and Akershus (RETRO, Vold 1999) and the Integrated model of residential and employment location in a metropolitan region (IMREL, Boyce and Mattsson 1999) were combined into the Transport- and land use planning model for the greater Oslo area – RETRO/IMREL (version 1.0). The report includes short descriptions of RETRO and IMREL and describes how IMREL was modified and combined with RETRO.

III. RETRO and IMREL

RETRO is a four-stage transport model programmed in the C programming language that can be used for periods with peak and off peak traffic load. It includes route choice, destination choice, mode choice and travel frequency (Vold 1999). The route choice is calculated with EMME/2 for a real network covering 438 zones in Oslo and Akershus. A nested logit model (i.e., frequency, destination and model choice) calculates travel demand. RETRO is connected to a sub model for car ownership.

The original IMREL model consists of a submodel for residential location (RES) and a submodel for employment location (EMP). RES can be expressed in terms of a bilevel optimisation problem. There is one worker per household in RES, and each household requires one housing unit. EMP is of the multinomial logit type with a linear systematic component with variables for the location conditions in the employment zone, the rent level and accessibility to the work force.

IV. RETRO/IMREL

The RETRO/ IMREL model is designed to assess the effects of land use and transport policy instruments, where the effects are calculated relative to a reference scenario. Available policy instruments in RES are: (1) the relative changes in the number of area units that are regulated for housing supply in the zones and (2) upper and lower limits for the share of residences in the zones as relative to the shares in the respective zones in the reference scenario. Policy instruments in EMP are (1) the relative change in the total area available for employment location, (2) the number of pupils (17-19 year) in school, and (3) the number of students in universities. Vold (1999) describes the available policy instruments in RETRO.

Although the first version of RETRO/IMREL does only take into account the periods of peak traffic load, the RETRO sub model can be used to calculate the resulting off peak transport costs and demand. Variables for disutility, housing price in the zones and the transport costs between zones are all endogenously calculated in RETRO/IMREL. Disutility, housing price and transport cost are important factors in RES. There are many variables that affect disutility in the positive or negative direction. In the present version of RETRO/IMREL, disutility in a zone is only affected by population density in areas zoned for housing supply. We express density as the number of households per area unit that are regulated for housing supply.

In model applications, when the three sub models are run in loop, the sub models interchange data. The RETRO sub model use data for residential location and employment location from RES and EMP, respectively. The employment location sub model use data of residential location from RES and some exogenous data from RETRO, whereas RES uses data of employment location and some exogenous data from RETRO.

The model implementation of RES and EMP are based on the C-version of the constrained optimisation algorithm DONLP2 (7/99), which is developed by P. Spellucci, Technical University at Darmstadt. The 1st level problem is represented according to the input specifications of DONLP2.

V. Data and model estimation

Input data and data for estimation of the RETRO/IMREL model were collected for the period around 1998. The data describes population subgroup sizes, the total number of jobs, the number of jobs that attracts people (grocer stores, service and restaurants) and data for the total shopping centre area. Data that are necessary as input to RES includes: (1) area available for residential purposes, (2) transportation costs and (3) travel demand and (4) upper and lower limits on the proportions of the total population that can live in the different zones. The input data to EMP includes (1) attraction indicators for employment location in the zones and (2) area available for work place location and (3) the maximum number of workplaces per area unit available for workplace location.

The attraction indicators constitute a measure for the accessibility to the work force and several data, corresponding to policy instruments, that describe the attractions in the zone. The measure for accessibility to the work force includes data for the transport costs (NOK) between all pair of zones in the area and the share of housing supplies in the zones.

Model estimation is based on methods that adjust parameters such that data and corresponding endogenous model variables fit. For RES, the endogenous model variables are the share of households in the zones, and for EMP the endogenous variables are the share of workplaces in the zones. For estimation we needed additional data for household- and employment location for 1998 for the 49 zones (27 municipalities in Oslo and 22 counties in Akershus) and an OD matrix for the total number of trips in the peak period in the base scenario.

The methods for parameter estimation did not require iterated interactions between the sub models while estimating the parameters. For estimation of RES, the method of maximum likelihood a dual formulation of RES was applied. The Nelder-Mead simplex algorithm for optimisation of non-linear functions was used for optimisation. Linear regression was used to estimate parameters in EMP.

In order to apply the model for a future time period, input data for the future time period is needed.

VI. Model application

A simple model application is presented, where two alternative scenarios are simulated and compared relative to a base scenario, where the base scenario describes the situation in the period around 1998. One of the alternative scenarios differs from the base scenario in that the fuel tax is tripled, and the other alternative scenario differs in that the toll ring charge is quadrupled. Moreover, the total number of residences and workplaces in the base scenario and the alternative scenarios are equivalent.

In the scenario with a tripled fuel tax, both the number of residences and the number of workplaces increase in areas close to the city centre. However, there is an insignificant increase in the number of residences in the city centre, where the area for residential purposes is small and the number of residences is small in the base scenario (ca. 1000 residences). The number of workplaces in the city centre increases by 30% relative to the base scenario. Also in the scenario where toll charges are quadrupled, we obtain a centralisation in areas that are close to the city centre. Different from the scenario with an increase in the fuel price is that we also get migration of households and work places to the Asker municipality some distance south west of Oslo. This is because more households and work places inside the toll ring increases the disutility in these zones, and a share chooses instead to establish in Asker instead in which there are many residences and workplaces initially in the base scenario.

VII. Conclusion

As prices change, it takes time before household- and workplace location again is in equilibrium. RETRO/IMREL calculates the long-term effects of changed prices. This means that the results are for a future year, where household- and employment locations have reached a new equilibrium. We can not say how long time it will take before the new equilibrium is reached. The time horizon depends on how narrow we set the intervals that are bounded by the upper and lower bounds on shares of residential - and employment location and the size of the areas available for different purposes. In real life it seems reasonable that at least 10 years is needed to capture a significant trend.

This report describes RETRO/IMREL - a combined land-use and transport model for the greater Oslo area and applications on simple test cases. Equilibrium models for transport- and land use planning like RETRO/IMREL are not expected to be capable to assess a very precise forecast for the amount of relocation among the zones relative to a base case. It is expected, however, that results from models of this type are reasonable and that the trends are reliable.

The qualitative and quantitative model behaviour in the test cases we have presented in this report seems reasonable. The cases were simple, however, so further development, validation and use is required in order to obtain more interesting results.

For future work, it would be interesting to include exogenously given variables in the disutility function. Interesting in this respect would be to include a variable that represents the service level, the availability for parking places, external environmental costs and a property tax. New variables for description of the establishment of workplaces would also be interesting. For this purpose it would be interesting to include an endogenously calculated variable that express the concentration of workplaces or the closeness to other workplaces.