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Author: Trond Jensen
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Summary:

A study of residential and employment location effects of a road price in the Greater Oslo area

A spatial general equilibrium approach

Background

The purpose of this work has been to study residential and employment location effects of a road pricing scheme in the Oslo and Akershus area. The road price is represented by an increase in the rush hour toll fee at existing toll ring in Oslo. We do not question the purpose of the road price itself, which is to introduce marginal cost pricing in the road system and to internalise external costs, but aim solely at the study of location effects caused by increasing costs in the transport system, and consequently increased commuting costs, in the Greater Oslo area.

The question we try to answer is how a road price, and thereby increased commuting costs, will influence households' decision of where to supply labour and where to locate. Such decisions by households to relocate labour and housing will again influence the real wages and land rents in different parts of Oslo, and thereby generate geographical and structural changes both in the local community and industry.

In this work we have been particularly concerned by the influences on the centre/periphery relation, and we have tried to identify which areas in the Greater Oslo area are the most sensitive to such location, real wage and land rent effects.

The model

Our subject includes effects in several markets and can be characterised as complex. This is why we need a simplified representation of the reality in the form of a small model. The model is a simple integrated land use and transport model for Oslo and Akershus called TRAM (Jensen, 1997). The model approach has been of great help for us in keeping track of all the relationships in this system of markets, and the analysis would have been impossible without this model.

TRAM is based on classical economic theory. The solution to the model is a static free competition market equilibrium comprising land use, employment, commuting, production, consumption and leisure in 11 zones in the Oslo and Akershus region. The zones, which are shown in the table below, are aggregates of townships within Oslo and the surrounding municipalities outside Oslo.

The zones 1, 2, 3 and 6 are completely inside the toll ring. Zone 4 and 5 are partly inside and partly outside the toll ring. Zones 7, 8, 9, 10 and 11 are completely outside the Oslo toll ring.

A market equilibrium in TRAM is characterised by a set of (relative) prices, activities (volumes) and income which clear all markets in all zones simultaneously. The model can be applied for simulating the effects of different policy instruments in both the transport

sector and within land use. In this work TRAM is being used for studying a transport policy instrument.

Table I. The zones in TRAM

TRAM	Municipality	TRAM	Municipality	TRAM	Municipality
Zone 1 z1	26. Sentrum	**Zone 5 z5**	14. Helsfyr-Sinsen 15. Hellerud 16. Furuset 17. Stovner 18. Romsås 19. Grorud 20. Bjerke	**Zone 9 z9**	0214 Ås 0215 Frogn 0216 Nesodden 0211 Vestby 0213 Ski 0217 Oppegård 0229 Enebakk
Zone 2 z2	1. Bygdøy-Frogner 2. Uranienborg-Majorstua 3. StHanshaugen-Ullevål	**Zone 6 z6**	21. Grefsen-Kjelsås 22. Sogn 27. Marka	**Zone 10 z10**	0227 Fet 0231 Skedsmo 0230 Lørenskog 0233 Nittedal 0234 Gjerdrum 0228 Rælingen
Zone 3 z3	4. Sagene-Torshov 5. Grunerløkka-Sofienberg 6. Gamle Oslo	**Zone 7 z7**	23. Vinderen 24. Røa 25. Ullern	**Zone 11 z11**	0235 Ullensaker 0238 Nannestad 0239 Hurdal 0236 Nes 0237 Eidsvoll 0221 Aurskog-Høland
Zone 4 z4	7. Ekeberg-Bekkelaget 8. Nordstrand 9. Søndre Nordstrand 10. Lambertseter 11. Bøler 12. Manglerud 13. Østensjø	**Zone 8 z8**	0219 Bærum 0220 Asker		

TRAM has one representative household, who demands land for housing purposes in all 11 zones, and 3 production activities, industrial production, private and public services, within each zone which demands land for production facilities. With one exception, which is public services there are free competition for land in each zone among residential and production activities.

Land is represented by floor space in TRAM, and the model does not allow investments in new buildings. This implies that we are modelling on a medium term time span. The time span is too long for isolated analyses of transport changes and too short for investment analyses. Our time span of 3 to 5 years should be interpreted as the time it takes for the economy to reach a new equilibrium.

Households demand leisure, housing, consumption goods and commuting services by three different modes. By assumption, commuting is carried out in the rush hour. The household choose where to live and where to work. The decisions are founded on generalised travel costs and real wages in different zones. Generalised travel costs consist of infrastructure and travel time, and commuting is the only travel purpose represented in TRAM. The three modes are car, public transport and walking/cycling.

The production sectors use land and labour as input in the production of consumption goods for the households. The technology of transforming input to output is different in different production sectors and in the same production sector located in different areas. The consumption goods produced in one production sector are in fact slightly different from the same goods produced in the same sector in a different zone.

Each zone can be looked at as a small economy, and there is trade of goods and labour between the zones. The trade is carried out by use of the transport system, but we do not account for transport of goods and shopping in the present version of TRAM.

The parameters in TRAM are based on data from 1992, and the models' benchmark solution will reproduce the transport, location and industry structure reflected in the benchmark data set. The data are collected from different sources put together to form a

complete representation of the commuting-, production and dwelling pattern in Oslo and Akershus in 1992.

Analyses

We have implemented the Oslo toll ring in TRAM. The initial toll fee is today's fee for a 175 trip pass at 1600 NOK, which is the most cost efficient payment schedule for daily commuters. In the present analysis we increase the present fee by 4 times to represent the theoretically optimal road price (Larsen Odd, 1997).

The primary effect of a higher toll fee is that commuting by car becomes more costly for those who cross the toll ring at their dailytrip to work. A higher relative price for commuting by car will induce workers to use one of the two alternative modes, public transport or walk/cycling, for commuting purposes if they have to cross the toll ring. Increased demand for public transport will again tend to increase the prices for this mode (not so for walk/cycling). The substitution between car and the alternative modes will reduce road transport, and the income effect of the increased fee will reduce the total amount of transport.

Increased commuting cost for those who cross the toll ring implies a decrease in disposable real wage for these households. As a consequense, households have to reduce other expenditures in order to remain within their budget. This can, however, be avoided by relocating their work place to a zone where they avoid the toll fee. Because of the present workplace/dwelling structure in the Oslo area, this will tend to decrease labour supply inside the toll ring and increase the supply on the outside of the ring. Producers on the inside of the toll ring will then have to increase their wage offers in order to keep their employees in competition with the employers on the outside of the ring.

Figure 1. Percentage change in households living in the different zones after the introduction of a higher toll fee

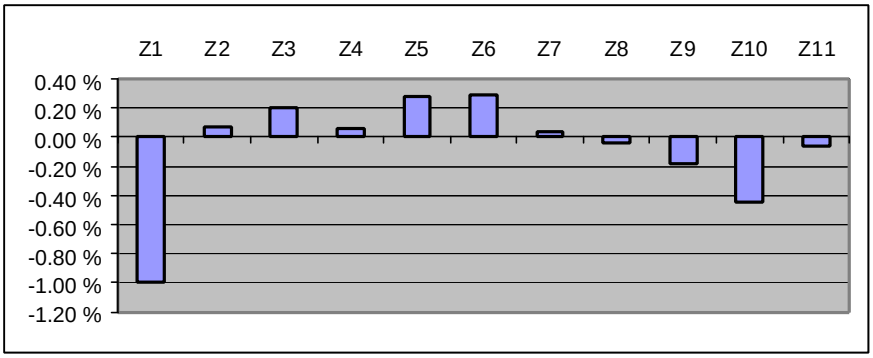
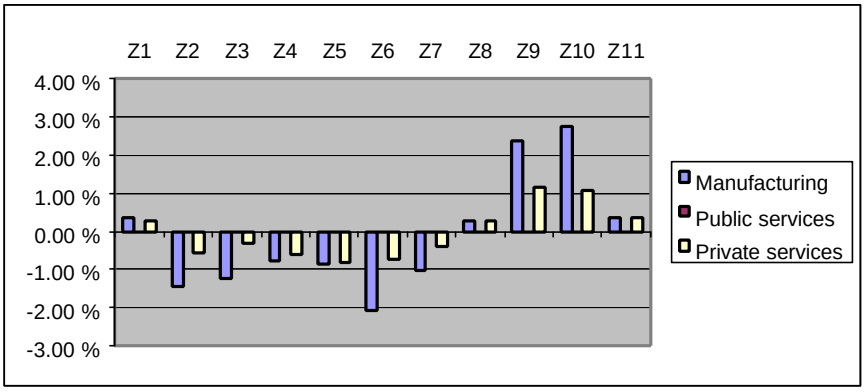


Figure 2. Percentage change in production activity in the different zones after the rise in the toll fee



Beside the relocation of work places it is also possible for households to relocate their dwelling. The net effect of households relocations is a movement of households toward the inside of the toll ring. The first figure shows the percentage change in households living in the different zones after the introduction of a higher toll fee.

Increased demand for housing inside the Oslo toll ring increases land rent, and reduced demand for housing outside the ring have the opposite effect. This means that employers inside the toll ring is faced by both higher real wage and higher land rent, while the opposite has occurred on the outside of the ring. This will make it a better strategy for some employers to relocate to zones outside the toll ring. The second figure shows the percentage change in production activity in the different zones after the rise in the toll fee.

We can conclude that the increased price on road transport across the Oslo toll ring, will increase the number of households who wants to live on the inside of the ring. This will increase land rent and the price for buildings in the same area. On the other hand, the remaining households outside the toll ring will decrease their labour supply to the centre of Oslo.

The net effect of increased housing demand and reduced labour supply from the households on the outside of the toll ring, is reduced labour supply inside the ring. This will tend to increase real wages and land rent in the centre of Oslo and thereby increase production cost inside the Oslo toll ring. The opposite will take place on the outside of the ring. This is a situation where it will be profitable for some employers to relocate outside the toll ring. In particular it is the Follo region and the southern part of Romerike that will gain from this situation. In the transport system we will have more public transport, more walking/cycling and less road transport for trips which have to cross the toll ring.

The important features of our results are confirmed in a study by A. Anas (1999). He finds that a congestion toll increases land rent and real wage in the city centre and induce employers to relocate from the CBD to the outer part of the city. Households tend to relocate to the inside of the CBD in order to avoid the congestion fee. Contrary to our results, however, Anas finds that the net result of employers tending to move out from the CBD and employees moving in to the CBD, is a denser city. This difference could be explained by empirical differences in the city structure in Oslo and Anas' city, or by Anas' assumption that land can be substituted for labour within a given zone, which is different from the production technology in TRAM.

Some parameters (mainly elasticities) in TRAM are not empirically well founded, and we have done several sensitivity analyses in order to investigate the robustness of our results. Based on these analyses we have discovered how and to which magnitude the different parameters influence our results. The sensitivity analysis have also shown us which parameters which influence different parts of the model system. The full results of the sensitivity analysis is shown in the appendix in this report.

The sensitivity analysis shows that the magnitude, but not to the same extent the trend of our results depends on the value of uncertain elasticities. The elasticities that govern location of housing and employment, have effects on the magnitude of the location swings, but means less for the transport system (distribution among transport modes). Except for one parameter in the congestion function (the reservation price), the elasticiteties in the transport system have very little impact on the location pattern but a lot on the behaviour of the transport system when it comes to changing the pattern of location. The general level of the commuting costs are the important factor in the transport system. However, it seems that the elasticities that govern the location system are more important for the behaviour of the transport system thanvice versa. This is not unexpected, because there are not the same access to the different transport modes in all zones.

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The report can be ordered from:
Institute of Transport Economics, PO Box 6110 Etterstad, N-0602 Oslo, Norway
Telephone: +47 22 57 38 00 Telefax: +47 22 57 02 90