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Summary:

Urban transport under different conditions

A comparative study of the connection between the framework conditions for urban transport and travel patterns in Norwegian and foreign cities

The Ministry of Transport and Communications has awarded the Institute of Transport Economics the task of carrying out a comparison of the urban areas which are taking part in trials of alternative administrative organisation of public transport provision. The main purpose is to illustrate the extent to which the cities which are taking part in the project have, relatively speaking, more or less effective operation of the transport sector based on the means which are available, and a higher or lower proportion of pedestrian, cycle and public transport journeys based on market-related assumptions. A comparison of target achievements of the trials of administrative organisation requires broad charting of framework conditions and assumptions for each individual urban area. In order to assist in this work, a larger database consisting of 43 cities, of which 28 are European, has been used.

Models for framework conditions: travel patterns

An explanation is given of models which demonstrate connections between public transport framework conditions and the public's travel patterns. Multiple linear regression is used. The models are based on the UITP database, which contain information about personal transport from a total of 84 cities. Oslo is the only Norwegian city which is represented in the database. The database uses 1995 as the reference year. The objective is to isolate the effects of different relevant conditions which affect the quality of the transport provision, volume of travel and the distribution between cars and public transport on an aggregate level. The figure below shows how we imagine these connections.

The quality of public transport, depending on whether it concerns the road network or public transport provision, will be decided by the *economic framework conditions*. By economic framework conditions, we mean the general economic level in the urban area and more specific investments and running costs connected with the different sides of the transport system. *The extent of travel* will be decided by the quality of public transport and the main framework conditions connected with the characteristics of the urban area *The choice of transport,* when we analyse the data at the aggregate level, will be decided directly or indirectly by the quality of the provision and other framework conditions connected with the characteristics of the urban area. The indicators which appear to be best suited to the model are:

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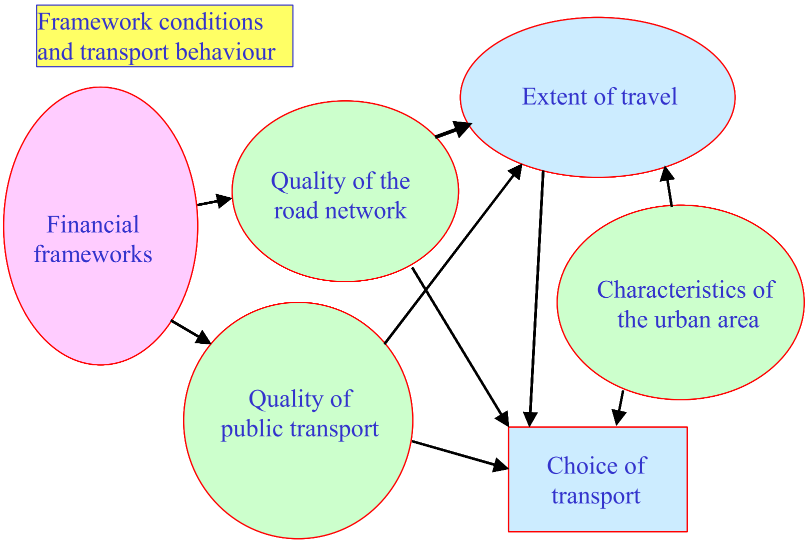


- *Economic frameworks*: Investments in the road network; investments in public transport; running costs for public transport; economic activity in the area.
- *Characteristics of the road network*: Road length per inhabitant; surface coverage for the road network; costs of using cars; parking places in the city centre; speeds on the road network.
- *Characteristics of pubic transport*: Surface coverage; vehicle fleet kilometres; size of fleet; costs of travelling by public transport; speed of public transport; separated public transport tracks; trams as a proportion of the number of routes, underground trains as a proportion of the number of routes.
- *Characteristics of the urban area*: Size of population; density of population; car density; economic activity in the area.
- *Extent of travel*: Number of journeys per person per day; average length of journey; length of journey to work.
- *Choice of form of transport*: Public transport's share of all motorised transport

Among the 84 cities in the database, a total of 43 cities have been selected, whereof 28 are West European. Thus, we have a more homogenous selection of cities, which are better suited for comparison with Norwegian conditions.

Model for the quality of the transport system

The sub model for the quality of the transport system shows the connection between central characteristics of the quality of the road network and public transport and the economic framework conditions for these parts of the transport system. The quality of the provision in this context can be used as an expression of the degree of adaptation for using the two alternative transport systems. To create indexed dependent variables for the model, information about the following has been used:

The quality of the road system/ adaptation for cars:

- Public road length per inhabitant
- Length of motorway per inhabitant

- Surface coverage of the road network
- Accessibility on roads measured in driving speed
- Number of parking places in relation to work places in the city centre
- Costs of using a car per person km (calculated as the proportion of local GNP per inhabitant in the area)

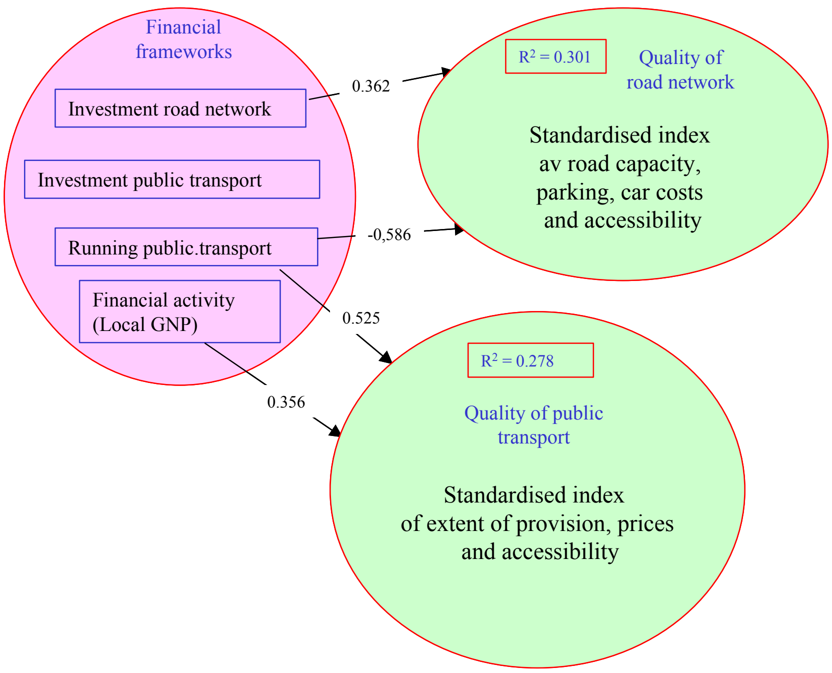
Quality of the public transport system / adaptations for using public transport:

- Number of public transport vehicles per inhabitant
- Surface coverage of the public transport network
- Public transport fleet kilometres in relation to the population
- Accessibility measured in driving speeds
- Costs of using public transport (calculated as the proportion of local GNP per inhabitant in the area)

As independent variables, we have used information about:

- Local gross national product
- Proportion of local GNP which is spent on road investments
- Proportion of local GNP which is spent on investments in public transport
- Proportion of local GNP which is used for running public transport

The figure below shows the effect of the dependent variables on the two indexed dependent variables.



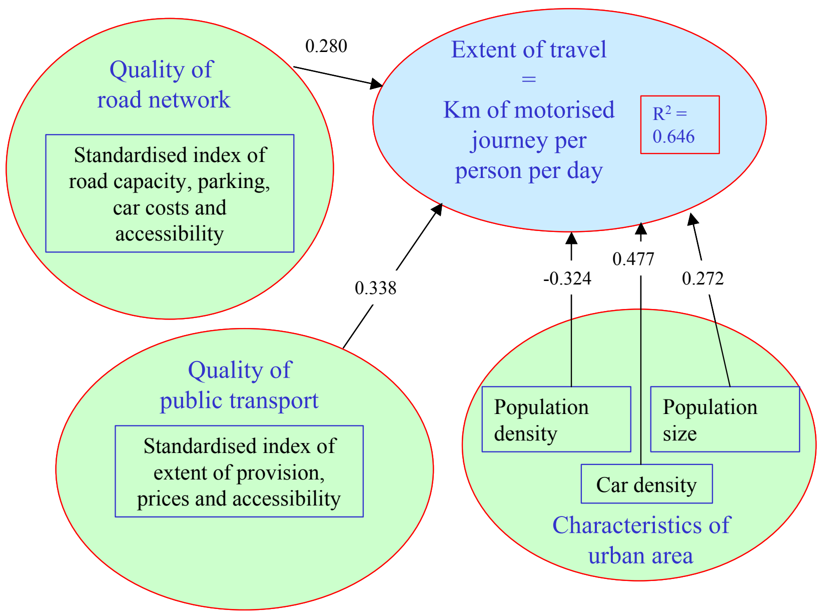
The models only explain a small proportion of the variation in the quality of the road network and public transport provision. The running costs of public transport form the single most significant factor, but we also find effects of the general economic activity and of investments in the road system. In cities where a relatively large amount is spent on public transport running costs, the probability of finding good public transport provision is high, while at the same time the adaptations for car usage will be correspondingly poorer.

Model for volume of transport

In the model for calculating the connection between the volume of transport and framework conditions, the following indicators are used as independent variables:

- Framework conditions connected with the area: Density of cars, size of population, density of population and economic activity in the area. (Metropolitan Gross Domestic Product)
- Framework conditions for using cars: Road capacity, accessibility, vehicle costs and parking conditions
- Framework conditions for use of public transport: Extent of provision, accessibility, fares

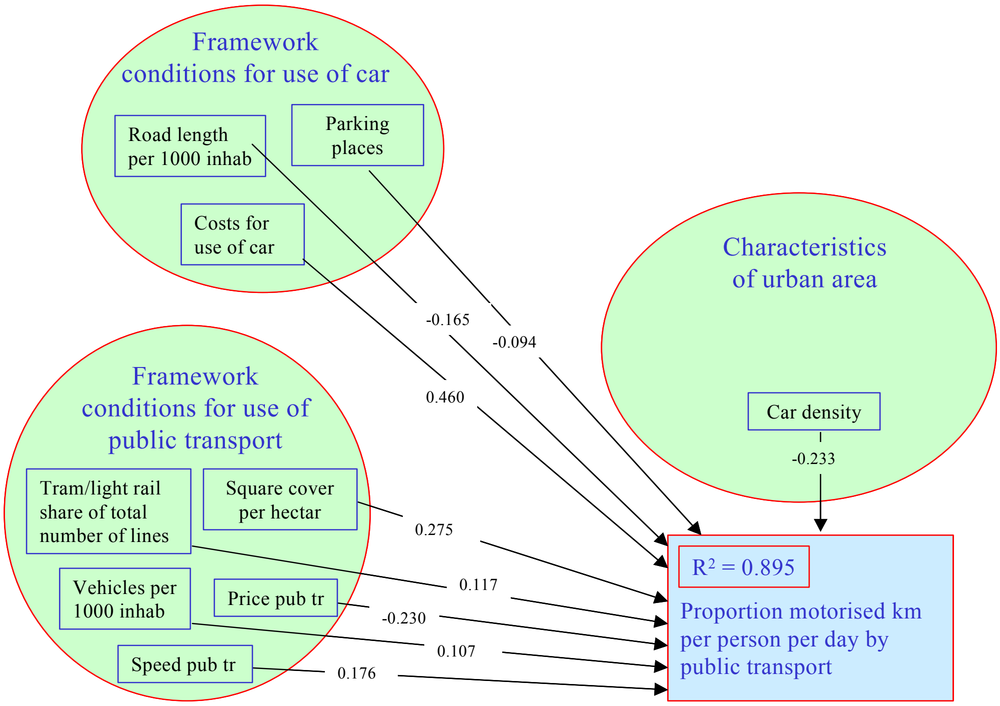
The figure below shows the factors which are significant for the volume of transport.



The model explains in detail two thirds of the variation in transport volume between the 43 cities. High car density, a large population and a high quality of public transport provision increase the probability of the population travelling a great deal locally, while a high density of population in the urban area has the opposite effect.

Model for choice of transport

The main purpose of the analysis is to demonstrate significant effects of the framework conditions on the population's choice of transport, which is defined here as the choice between private and public motorised transport. A total of 17 indicators are used in the analysis, and nine of them are shown to have significant effects. The figure shows the connection between these nine factors and the proportion of transport carried by public transport.



The model can explain almost 90 percent of the variation in the choice of transport (r^2 = 0,895). The results of the analysis can be summarised briefly thus. The proportion of public transport increases when:

- Public transport fares are reduced (the costs of using public transport)
- Public transport accessibility increases (journey speed increases)
- Frequency/capacity of public transport increases (number of buses per 1000 inhabitants)
- Accessibility to public transport increases (surface coverage)
- The standard of public transport increases (tram routes as a proportion of the total public transport line network)
- Car density is reduced
- The cost of using a car increases
- The road capacity goes down (number of metres of road per inhabitant)
- Parking capacity goes down (number of parking places per 1000 workplaces in city centres)

As a supplement to the regression analysis, a factor analysis has been carried out to classify the 43 cities according to how well they are adapted for private and public motorised transport. Bern and Zurich are best adapted for public transport, but it is important to note that these cities are not negatively loaded with regard to cars. On the contrary, they lean gently towards the positive pole in this dimension as well.

The cities in North America and Oceania are placed at the positive pole with regard to cars. Half of these lean in a negative direction with regard to public transport. The conditions in a number of the central European cities are well adapted for public transport, but here the conditions for car users are less favourable. Barcelona is not a good city for car drivers, but it is neutral with regard to conditions for public transport.

Finally, there are a number of cities which do not appear to be particularly adapted for any of the alternatives, for example Tel Aviv, and a number of the southern European cities, such as Athens, Marseille and Bologna.

The three Scandinavian capital cities are particularly interesting in that they appear virtually equally positive in both dimensions. Encouraging both forms of transport appears to be typically Scandinavian. This may be an expression for a conscious desire to achieve a balance between the alternatives, but it may also be a sign that there has been no desire to choose between main strategies.

Key figures for six Norwegian urban areas

The following municipalities are included in the comparisons:

- Sarpsborg/Fredrikstad: Fredrikstad and Sarpsborg municipalities
- the Kristiansand region: Kristiansand, Søgne, Songdalen, Vennesla, Lillesand and Birkenes municipalities For this region, figures are given both for the whole region and for Kristiansand municipality alone.
- The Stavanger /Sandnes region: Sandnes, Stavanger, Sola and Randaberg municipalities
- Bergen: Bergen municipality
- Trondheim: Trondheim municipality
- Tromsø: Tromsø municipality

Number of inhabitants in densely populated areas and **the population density** in this area are important framework conditions for the type of public transport provision which can be achieved. Bergen has the largest population, but the density is greatest in Trondheim. Stavanger /Sandnes lies between the two. On the basis of these criteria, these cities should be approximately equal, and better than the other urban areas with regard to opportunities to offer a good service. Kristiansand has a smaller population and lower density and thus has a poorer starting point. The starting point for Sarpsborg /Frederikstad, where the population is clearly the lowest, is even worse. Tromsø has the smallest population but at the same time, the density of population within the densely developed area is similar to Bergen and Stavanger /Sandnes.

There are significant differences between the cities with regard to **access to transport**. Fredrikstad /Sarpsborg has the highest vehicle density, with 590 cars per 1000 inhabitants between 18 and 79 years of age, while the proportion in Tromsø is lowest with 484. The Stavanger /Sandnes area has **the most buses**, where the **traffic load** carried by bus is also greatest. Sarpsborg/Frederikstad has the least buses and the least traffic load. When the two parameters are seen in relation to the size of population, Sarpsborg/Frederikstad retains its position while Tromsø clearly offers the greatest provision. There are two buses per 1000 inhabitants and 100 fleet kilometres are driven per bus per inhabitant per year. The **surface coverage**, measured here as the annual traffic load in relation to densely populated areas is four times as high in Tromsø as in Sarpsborg /Frederikstad. There is a small distinction between the other areas, which have a surface coverage approximately double the coverage in Sarpsborg /Frederikstad and half of that in Tromsø.

Sarpsborg /Frederikstad have low **passenger figures** and low **capacity utilisation**, while Trondheim has relatively high figures and a high level of utilisation. The capacity utilisation in Trondheim is exactly the same as that for buses in Oslo, when we look at the relationship between person kilometres and fleet kilometres. Kristiansand lies between these outer points. Tromsø deviated from this picture by having the highest passenger figures per inhabitant but where capacity utilisation is not particularly good. Stavanger /Sandnes has a lower capacity utilisation than Tromsø and Kristiansand, but a journey frequency, measured in passenger figures, which lies between these cities.

There are major differences in the cities in between with regard to public transport finances. Bergen municipality is in a special position with regard to both expenses and income. The **annual running costs** are double as high as they are in Trondheim. At the same time, **ticket income** is also highest here. The costs per vehicle kilometre do not vary particularly. They are lowest in Kristiansand at NOK 21.28 per vehicle kilometre and highest in Sarpsborg /Frederikstad at NOK 28.58. The variation in ticket income is much greater with NOK 10 per vehicle kilometre in Kristiansand as the lowest and 23.70 in Trondheim. This means that the **proportion of subsidy** varies considerably from 10% in Trondheim to 64% in Sarpsborg /Frederikstad. The running costs per inhabitant are lowest in Sarpsborg /Frederikstad and highest in Tromsø.

The greatest **road capacity,** calculated in relation to the number of inhabitants and the number of private cars, is found in Tromsø and the Kristiansand area, while it is lowest in Bergen and Trondheim. Here there is a close connection between city size and road capacity. The largest road capacity in relation to the total area to be covered is nonetheless to be found in Stavanger/Sandnes.

In all the cities, far more is spent per inhabitant on **running** public transport than on the road network. The difference is greatest in favour of public transport in Bergen, with a difference of NOK 1210 per inhabitant, and least in Sarpsborg/-Frederikstad with NOK 485 per inhabitant. In Bergen, approximately the same amount is spent per inhabitant on running public transport alone as is used on public transport and the road network together in the three other cities.

There are significant differences between the cities with regard to the **distribution of forms of transport.** The proportion of public transport is more than double in Tromsø than in Sarpsborg/Frederikstad. Furthermore, the variation in the proportion of public transport is closely connected with public transport provision in the six areas. The proportion of journeys on foot is very high in Bergen, while the proportion of journeys by bicycle is low. The fact that there are few journeys by bicycle in Bergen and Tromsø seems reasonable, taking into account the topography and the weather. Sarpsborg/Frederikstad stands out with the highest proportion of journeys by car and motorcycle.

Connections between choice of form of travel and framework conditions

There is a very close connection between the proportion of public transport and **population density** in urban areas. Tromsø and Stavanger/Sandnes deviate somewhat from this pattern by having respectively higher and lower proportions of public transport than the population density seen in isolation ought to indicate. These two areas have roughly the same population density as Bergen, but nonetheless clearly deviate from this city with regard to the proportion of public transport.

Car density and the proportion of public transport are closely connected, so that the proportion of public transport decreases when car density increases. Tromsø and Sarpsborg/Frederikstad are the clearest examples of this connection. The **degree of employment** is also correlated with the proportion of public transport, so that Tromsø, which has the highest proportion of active workers, has the highest proportion of public transport, and Sarpsborg/Frederikstad has the lowest. The **size of the bus fleet**, in relation to the number of inhabitants, is a good indicator of the proportion of public transport. Trondheim has a higher proportion of public transport than the size of the bus fleet would indicate, which means that capacity utilisation is better here than in the four other cities. **Surface coverage** is also closely connected with the proportion of public transport and again, Trondheim deviates somewhat from the general pattern, which confirms the relatively high capacity utilisation here.

Model calculations

Based on the results from the regression analysis for the connection between choice of travel and framework conditions, it is possible to carry out some simple model calculations, which can give an indication of the direction and strength of effects of different types of measures.

In order to demonstrate how the model can be used practically, we will begin with a discussion on the fate of the tram in Oslo. If we were to completely remove the trams and replace them with buses along the same routes, while everything else remained constant, the proportion of person kilometres by public transport would decrease by 2.7%. How does this change correspond to other changes in the framework conditions, and how can the effect of replacing trams with buses be neutralised? The same effect can be achieved by replacing trams with buses so that:

- The cost of using a car go down by 5.7%
- The number of parking place in the city centre goes up by 50%
- Car density increases by 5.7%

Conversely, the effect of replacing trams with buses can be neutralised by:

- Reducing fares by 9%
- Increasing driving speeds for public transport by 4.5%

Model calculations have been carried out for Kristiansand in order to look closely at the measures which can be implemented to achieve a target whereby most of the expected growth and traffic will be covered through the use of public transport. In order to achieve this goal, we can choose several different types of measures. If we choose to concentrate on public transport measures, accessibility and raising standards appear to be the best measures. Furthermore, we could also consider a small reduction in fares outside rush hour. As well as these measures, the route network and capacity must be dimensioned so that a best possible, optimal utilisation of the resources is achieved in relation to where the traffic basis is greatest.

An alternative approach is to start with a package of measures and to see what effect this would have. An example is where a change in public transport provision is combined with a restrictive measure in regard to car traffic, in this case, a reduction on the number of parking places in the city centre.