Public transport in towns: Inevitably on the decline?

Johan Holmgren, Jan Owen Jansson and Anders Ljungberg

Original Publication:

Johan Holmgren, Jan Owen Jansson and Anders Ljungberg, Public transport in towns: Inevitably on the decline? 2008, Research in Transportation Economics, (23), 1, 65-74.
http://dx.doi.org/10.1016/j.retrec.2008.10.011

Johan Holmgren, Jan Owen Jansson and Anders Ljungberg

PUBLIC TRANSPORT IN TOWNS – INEVITABLY ON THE DECLINE?

1. Problem, purpose and delimitation

Local public transport development in Sweden, like in many other European countries, has for a long time been on the decline, except in the very largest cities. The number of public transport trips per person in Stockholm has increased a little in the last two decades. Because of the size of the population in the capital and the relative importance of public transport in the transport system of Stockholm, this increase obscures the fact that the decline of public transport in all urban areas apart from Stockholm has been very significant: from 1986 trips per person has gone down by a third.

A similar pattern is found in Great Britain. According to Balcombe et al (2004) local bus transport has been halved between 1970 and 2000.

The question is if local public transport in towns is a species under threat of extermination? If the decline represents a natural evolutionary process, where a more competitive mode of transport is replacing a less competitive mode, it should perhaps not be objected to? And could it be prevented? Just like long-distance passenger transport by rail in the USA, which was biggest in the world in the interwar period, but has shrunk to sheer insignificance under the pressure from the private car and air transport, public transport in towns could be wiped out by superior competition from individual short-distance modes of travel (cars and bicycles).

In the large cities, growing car traffic congestion justifies quite strong countermeasures including heavy investments, in particular in rail-borne public transport, and road pricing, which should induce a wholly different development. In most towns the required funds for financing the public transport upgrading that could make a difference are lacking, and the traffic congestion is not serious enough to justify road pricing. Nevertheless, in political declarations both local and national politicians in Sweden have for some time strongly expressed the view that for environmental and other reasons the present trend of decline of local bus transport should be reversed. However, as public transport costs are growing faster than the farebox revenue, the action in practice does not suit to the words.

The purpose of this chapter is to address the basic question, whether an optimal local public transport policy in towns, from a social point of view, would make a difference. Could it break the trend and turn the vicious spiral into a virtuous one? Or is a gradual phasing out of local bus transport consistent with a sustained social surplus maximization policy?

These questions will be addressed primarily by a case study of the town of Linköping. The population of the Linköping municipality is 140 000. Bus is the only mode of local public transport like in most medium-size cities, and all smaller towns in Sweden. Besides Stockholm there are three cities with local tramways supplementing the bus lines. This chapter is about bus transport in towns, so for our purpose the definition of a "town" could be a built-up area too small for rail-borne public transport as far as local travel is concerned.

2. Institutional setting and outline of the chapter

Local public transport policy in Sweden is determined by politicians at the county level. Both the network design, including the frequency of service of each particular line, and the pricing policy are politically decided. The desirable quality of service and the current level of fares are not, by far, consistent with a self-financing regime. Therefore some 50% of the total costs of local public transport is financed by local (county) taxes. The subsidization is ranging from 28% to 74% among the 21 county public transport authorities. In order to counterbalance the ever-growing costs of local public transport services, competitive tendering for carrying out the specified services, given the fares, is nowadays quite common. (SLTF 2002 gives an overview of the organization of local and regional public transport in Sweden). The problem, as we see it, is that although a subsidy is, in principle, justified, it does not give full value for the money.

The decline of public transport in Linköping has been even worse than in other towns in Sweden. That it was strongly on the increase up to the beginning of the 1980s is now almost forgotten. As seen in Figure 1 total local bus trips in Linköping increased from 2.5 millions in 1947 to 21.5 millions in 1983, while the population increased from about 50 000 to 83 000 in the same period. This strong expansion should be explained in order to understand the causes of the trend-break and the decline in the following period. The decline that started in the beginning of the 1980s, in spite of a steadily growing population, means that in terms of trips per person we are now back at the level of the beginning of the 1950s.

FIGURE 1 ABOUT HERE

Figure 1 *Post-war development of public transport in Linköping*

It can be suspected that the decline in the last 25 years to some extent is self-inflicted. The typically short-sighted politicians are cutting services in the hope of making ends meet, without realizing that supply reductions may also have a significant negative effect on demand, so the discussion will start by examining the nature of the vicious spiral. In order to test the hypothesis that the growing car dominance is just an example of the survival of the fittest, another concern of the demand analysis is to get the income elasticity right. If it turns out to be very small, or even negative, which has been found in some studies, the boosted aim of local public transport enhancement may be in vain in the long run.

After the demand analysis in sections 3 and 4, the next question is what it would take to break the trend again, and turn the vicious spiral into a virtuous one in the future?

One should not try to obtain growing bus transport patronage at any costs. The guiding star should be economic efficiency in its widest sense, so the most relevant question is: suppose that public transport investment and pricing policy were reoriented to aim at net social benefit maximization without constraints, would that break the trend in the use of bus transport?

To answer this question, we have to determine in section 5 what the optimal system would look like in rough outline, and estimate the generalized cost difference between the present and the optimal situation. The positive “shock” by which the public transport system in Linköping should be stimulated, is the reduction in fares, and improvements in the quality of service, and other possible system changes that follows from the new goal. If that will be sufficient in the long run for a sustained virtuous development, is an open question. Section 6 finally, offers some conclusions.

3. A direct demand model for explaining the post-war development of local bus transport in Linköping

The estimation of the relationships required for answering these vital questions can be based either on data from travel surveys of individual travel choices or on recorded, aggregated market data. In our research we have chosen the latter approach.

The former approach would be particular useful for analyzing the modal split, but when it comes to studying changes over a longer period of time of aggregate travel demand and how it depends on the pattern of urban development, technical and social changes, direct demand models are more useful. The drawbacks are certainly that individual differences concerning both socio-economic characteristics and qualities of public transport services, such as walking distance to the bus stop and service frequency, cannot be taken into account. Broad aggregates such as vehicle-kilometres have to be used as imperfect surrogates. Direct demand models can be said to combine the effects of trip generation, distribution and mode choice (Ortuzar and Willumsen 2001, Balcolme et al 2004). Sometimes the models are derived through maximization of a specified utility function, but various *ad hoc* assumptions as to the functional form are more common (Holmgren 2007).

Direct demand models are often used to estimate aggregate demand elasticities, and like in this chapter to make forecasts at an aggregate level. Webster and Bly (1980), Oum et al (1992), Goodwin (1992), Balcolme et al (2004) and Holmgren (2007) provide overviews of previous results from direct demand models. Conceptually these models are related to microeconomic theory in the basic sense that demand for a specific mode of transport (in this case local bus transport) is assumed to be a function of price and quality, income and other socio-economic variables. The competing modes of transport (car, bike, walk) are taken into account simply by the current average rate of car ownership, and as regards the non-motorized travel modes, typically not at all. This will not do. Travel by foot and bicycle is highly distance-dependent, and since the average travel distance tends to increase with the size of the built-up area of a town, walking and bicycling are very competitive in small towns, and bicycling is up to the mark also in medium size towns[1]. As a proxy for the decreasing competitiveness of the non-motorized modes of travel as the built-up area of Linköping has been expanding, we are using the ratio of the outer suburban population to the central city population in the following regression analysis.

Our main hypothesis is that the fairly dramatic post-war development could to a large extent be explained by some strong exogenous forces, unique to particular periods in the second half of last century. The increase in female workforce participation was quite strong in the 1960s and 1970s. The build-up of the Swedish welfare state implied a boost nationally of the typical female professions in health, child- and eldercare, from 3% of total employment in 1960 to 20% in 1980. In Linköping the female labour force participation increased from 38 % in 1960 to 78 % in 1985.

Since then female users have dominated public transport patronage. In the beginning of the 1980s a trend-break occurred in public sector employment. The increase stopped and public employment has been largely constant since then. When the increase in the female rate of employment slowed down in the 1980s, a negative effect on the demand for public transport became noticeable. Female car ownership had been growing for some time, but its negative

[1] Nowadays, there is a revival of bicycling in Stockholm and Gothenburg as well. The model split, however, is still much more walk and bike oriented in smaller towns in Sweden.

effect on public transport patronage had not been noticed until the female employment rate ceased to increase. From the beginning of the 1980s up to now female car ownership has increased by 50 per cent. Male car ownership was almost saturated already in the 1970s, and has increased only by 6 per cent in the last forty years.

Besides the increase in female workforce participation, another factor that might account for the expansion of public transport before 1985 is the thorough change in city structure. In the beginning of the post-war period, 32% of the population in Linköping lived in the central city and thereby within easy walking and biking distance of most services and workplaces in the town. 57 % lived in the inner suburbs, and only 11% in the outer suburbs of the town. By the time public transport had reached its patronage peak no less than 67% lived in the outer suburbs. Since then the town has become somewhat more compact; 59% now live in the outer suburbs. A hypothesis is that people living in the central city do not need bus transport to the same extent as people in the outer suburbs.

3.1 *Regression analysis*

These conjectures have been tested by regression analysis of the post-war period in Linköping. Number of trips per capita (q) is explained by bus fare (P), vehicle kilometres per km^2 (v), average income (Y), rate of car ownership (C), female labour force participation (FE), and the proportion of the population living in the outer suburbs (c3). Fare and car ownership are expected to have a negative effect on demand while vehicle-kilometres, female labour force participation, and the proportion of people living in the outer suburbs are expected to have a positive effect. The sign of the income effect is uncertain (Holmgren 2007) but since car ownership is included in the model it could be expected to be positive.

Since regression on non-stationary time series might lead to spurious results, the series included in the model were all tested using an augmented Dickey-Fuller test (Greene 2003). It was concluded that none of the series is stationary and therefore a model was estimated using the data in first difference form. The estimated demand equation is: [2]

$$\Delta \ln q_t = \alpha_0 + \alpha_1 \Delta \ln P_t + \alpha_2 \Delta \ln v_t + \alpha_3 \Delta \ln Y_t + \alpha_4 \Delta \ln FE_t + \alpha_5 \Delta \ln C_t + \alpha_6 \Delta \ln c3_t + \varepsilon_t$$

The model was estimated using 2SLS where all the predetermined variables (including ΔV_{t-1}) is used as instruments. Income was found insignificant at any reasonable level and therefore excluded from the model. The lack of a significant direct effect of income might seem surprising but is in line with previous studies, Holmgren (2007) found that elasticities ranging from -0.82 to 1.18 is reported in the literature. The result in this study, as well as the variation in previous results, might reflect that income does not have a direct effect on public transport patronage. However, since the lack of statistical significance does not necessarily imply that there is no effect, the question of the income effect is still unresolved. The results from the estimation are shown in Table 1.

Table 1 *Result of regression analysis of the development of bus trips per person in Linköping 1946-2006*

TABLE 1 ABOUT HERE

[2] In order to achieve the target rate of capacity utilization the operator is assumed to adjust vehicle-kilometres so that: $\Delta V_t = \beta \cdot \Delta Q_t + \lambda \cdot \Delta V_{t-1} + \delta_t$, where V denotes total vehicle-kilometres and Q denotes total number of trips.

All variables have the expected sign. The elasticities seem to be in line with previous results, although the fare-elasticities seems somewhat smaller in absolute terms than the average reported for example in a recent meta-analysis (Holmgren 2007).

3.2 *Causes of the trend-break*

It can be concluded that the virtuous spiral in the first three decades of the post-war period was induced by the rise in female employment, the expansion of Linköping with a growing proportion of the population in the outer suburbs, and the fall in real fares. The fall in real fares went on right up to 1978 when it had become just half in real terms of what it was 30 years before, that is, the nominal increase in fares had been considerably lower than the general inflation.

The remaining main force was quite a strongly negative influence from the growing rate of car ownership which went up from a very low level in 1950, when the car diffusion started in real earnest, to 166 cars per 1000 persons in 1960, 306 cars per 1000 persons in 1970 and 345 cars per 1000 persons in 1980. However, this negative force was not strong enough to prevent a virtuous spiral for the public transport development in Linköping until the beginning of the 1980s, when it turned into a vicious spiral. The steady increase in female car ownership – more or less coincident with the increase in the number of two-car households – has probably been the main cause of the decline in total bus trips which, as seen in Figure 1, started in the beginning of the1980s. That the real bus fare has increased by 46 per cent since 1980 has clearly been a contributory cause. And in this period of decline of bus travel, the countervailing force of an increasing rate of female employment was no longer present. This rate has stayed more or less the same right up to the present time.

4. Demand elasticities for the policy analysis

When now looking ahead, the question to be addressed is, if it would be possible to recreate the virtuous spiral. For this purpose two things have to be done: first the previous results of the regression analysis have to be developed to suit the purpose of the policy analysis, and, secondly, the optimal supply and pricing policy principles have to be laid down. In this section the first task is carried out, and the second task is carried out in section 5.

4.1 *Capacity and quality are joint products*

When it comes to policy analysis the specific feature of public transport, known as “jointness of capacity and quality”, which is unique to certain transport services has to be taken into account. This specific feature can be described as follows:

In an urban area where the public transport mainly consists of buses of a standard size the total capacity provided is well approximated by the total vehicle-kilometres (V). A confirmation that V is a good capacity proxy is the close correlation between V and total trips[3] by public transport (Q) in a cross-section of the urban areas of the 26 Swedish counties shown in Figure 2.

FIGURE 2 ABOUT HERE

Figure 2 *Plot of total public transport vehicle-kilometres against total trips by public transport (logarithmic scale)*

[3] Number of trips is better than passenger-kilometres for the present purpose, because the capacity required is mainly determined by the peak demand for travel through the critical section of each particular bus line, irrespective of the average trip length.

The point is that V is also a good proxy for some of the main qualities of public transport service in a particular town. The larger V is, the denser the bus line network, and/or the higher the frequency of buses on each line will be: capacity and quality of bus services are to a large extent joint products. The goal for running public transport services can vary among towns and cities, but one common aim should be to avoid excess capacity as well as excessive crowding on the buses in peak hours. In other words: public transport authorities and operators alike should aim at a well-balanced rate of capacity utilization. This is a cost efficiency condition, which should be met, no matter which other targets they want to attain.

Peak demand determines the total capacity requirement. In view of the substantial random element in demand, the rate of capacity utilization should not be 100 per cent, not even in peak hours because that would give rise to unbearable queuing at bus stops A target rate somewhat less than 100 per cent should be aimed at, by which completely full buses leaving some travellers behind should be a relatively rare occasion.

4.2 *The adjustment process*

In the diagram of Figure 3, where total vehicle-kilometres (V) are given along the vertical axis, and total trips (Q) along the horizontal axis, the slope of the ray from the origin represents the rate of capacity utilization, 1/k aimed at: V=kQ. The target rate does not necessarily have to be the same for each level of demand, but the linearity assumption facilitates the exposition, and is not crucial for the working of the model.

A number of demand curves are now brought into the picture. The shape of these curves is not the familiar one, since the demand determinant picked out for the two-dimensional illustration is not price but quality of service, approximated by the total vehicle-kilometres provided. Given a particular demand curve a provisional market equilibrium is ruling when the target rate of the capacity utilization is obtained.

FIGURE 3 ABOUT HERE

Figure 3 *The path from one market equilibrium (a) to another (n)*

The total vehicle-kilometres (V) is obviously not the only determinant of demand. For the present discussion we only need to specify price (P) and quality of service (V), as policy variables in the demand function, besides a vector X representing the exogenous independent variables.

$$Q = Q\ (P,\ V\ X) \qquad (1)$$

The partial demand elasticities with respect to P, V and X are written:

$$e_{QP} = \frac{\partial Q}{\partial P}\frac{P}{Q} \qquad (2a)$$

$$e_{QV} = \frac{\partial Q}{\partial V}\cdot\frac{V}{Q} \qquad (2b)$$

$$e_{QX} = \frac{\partial Q}{\partial X}\frac{X}{Q} \qquad (2c)$$

We shall now use Figure 3 to concretely illustrate how a vicious spiral is fuelled by the jointness of capacity and quality.

Suppose that the starting-point is the equilibrium position marked in the diagram by *a*, corresponding to trip volume Q_0 and the supply of vehicle-kilometres V_0. It is upset in the next period by an exogenous "shock" ΔX, which shifts the ruling demand curve to the left, and moves us to point *b* in a first step, corresponding to the lower trip volume Q_1, given the original capacity level V_0. However the rate of capacity utilization is then too low. In the hope that the target rate could be restored, capacity is reduced from V_0 to V_2, which corresponds to the vertical distance from point *b* to point *c*. This attempt to restore the target rate of capacity utilization is in vain because the quality of service has been reduced, which in turn lowers the quantity demanded from point *c* to point *d*. Now, we are again off the target rate of capacity utilization, and a further reduction of V is made, etc …. until the new final equilibrium position *n* is obtained.

The decrease in demand in the first stage from Q_0 to Q_1 can be approximated by the product of ΔX and the partial derivative of Q with respect to X.

$$Q_0 - Q_1 \approx \Delta X \frac{\partial Q}{\partial X} \qquad (3)$$

Similarly, the fall in demand in the second stage caused by the decrease of V from V_0 to V_2 (= ΔV) can be approximated thus:

$$Q_1 - Q_2 \approx \Delta V \frac{\partial Q}{\partial V} \qquad (4)$$

The total movement between the two equilibrium positions *a* and *n* has implied a total decrease in demand $Q_0 – Q_n$, which is substantially greater than $Q_0 – Q_1$ caused by the initial shock ΔX. The “total adjustment” effect on demand can be derived by total differentiation of the demand function (1) above, and an expression for the capacity requirement.

$$dQ = dP\frac{\partial Q}{\partial P} + dV\frac{\partial Q}{\partial V} + dX\frac{\partial Q}{\partial X} \qquad (5)$$

The assumed proportionality between the total volume of trips Q and total capacity is expressed thus:

$$V = kQ \qquad (6)$$

$$dV = k\, dQ \qquad (7)$$

When the process is triggered by a price rise dP, which in the end will result in a new equilibrium position, the same path to the new equilibrium as in Figure 3 can be used as an illustration. From expression (5) above for the total change in the number of trips dQ, the total adjustment elasticity of Q with respect to P can be obtained by first dividing through by dP and inserting kdQ for dV, giving us the following expression:

$$\frac{dQ}{dP} = \frac{\partial Q}{\partial P} + k\frac{dQ}{dP}\frac{\partial Q}{\partial V} + \frac{dX}{dP}\frac{\partial Q}{\partial X} \qquad (8)$$

Assuming that the exogenous determinants X are independent of P, the last term of (8) comes to zero. Then multiplying through by P/Q and inserting V/Q for *k* gives:

$$\frac{dQ}{dP}\frac{P}{Q} = e_{QP} + \frac{dQ}{dP}\frac{P}{Q} e_{QV} \qquad (9)$$

The short-run price- and quality-elasticities are defined in (2a) and (2b) above. The total adjustment price-elasticity is denoted E_{QP}:

$$E_{QP} = e_{QP} + E_{QP}\, e_{QV} \qquad (9a)$$

$$E_{QP}\,(1 - e_{QV}) = e_{QP} \qquad (9b)$$

$$E_{QP} = \frac{e_{QP}}{1 - e_{QV}} \qquad (10)$$

The total adjustment elasticity of Q with respect to X takes the same basic form:

$$E_{QX} = \frac{e_{QX}}{1 - e_{QV}} \qquad (11)$$

Since e_{QV} is positive and in all likelihood less than unity[4] – a value of 0.44 came out from the preceding regression analysis – it is clear from (10) and (11) above that the total adjustment elasticity of demand is larger than the corresponding short-run (partial) elasticity of demand with respect to all public transport demand determinants. At bottom it is the jointness of ca-

[4] Were $e_{QV} > 1$, the vicious spiral would soon result in complete extinction, and the virtuous spiral would lead to boundless public transport expansion.

pacity and quality which causes this peculiarity. Were V of no consequence for the quality of service, that is, were its effect on demand negligible, e_{QV} would be equal to zero, and the total adjustment elasticity would coincide with the short-run elasticity.

The usefulness of the total adjustment demand elasticities is that they make predictions possible that take into account the demand and supply interaction, as opposed to the partial demand elasticities. For example, in a policy analysis, suppose that a fare reduction is contemplated. Its total effect on demand is given by the total adjustment price-elasticity, which takes into account that the first-round increase in demand requires additional bus(es) which in turn gives rise to a further increase in demand, etc. Also when predicting the effect of changes in exogenous variables the total adjustment elasticities are relevant: if you want to predict the effect on the demand for public transport of a particular forecasted rise in the proportion of outer suburbs population, this cannot be based just on the partial c3 elasticity, because that does not consider the secondary effect on demand of the necessary increase in capacity caused by the primary effect on demand of the rise in the proportion of outer suburbs population.

Inserting the results presented in table 1 in (10) and (11) gives the total adjustment elasticities. Together with the partial (short run) elasticities they are shown in Table 2.

Table 2 *Short-run and total adjustment bus travel demand elasticities for the town of Linköping*

TABLE 2 ABOUT HERE

5. Proposed policy changes

There are many interesting policy changes to consider. Besides changes in fares and service levels, Webster and Bly (1980) discuss bus priority, park and ride, staggered work hours, car parking restrictions and traffic restraints. Several later studies for example Goldman and Gorham (2006), Curtis (2008) and Banister (2008) discuss, among other things, travel information, fare payment technologies, car- and bike sharing and land use changes.

We limit the following discussion of demand promotion to the policy variables considered in the previous regression analysis, and will now look at the bus transport services in Linköping in terms of social costs and benefits rather than in terms of bus company cost and revenue. The existing financial constraints are relaxed in this exercise, that is, neither the level and structure of fares, which in the actual practice are fixed by the principal, nor the subsidy which also is part of the deal between the principal and agent (the single bus transport operator running the whole system of bus lines in Linköping) are given, but regarded as variables to adjust towards an optimal public transport system.

At present, the public transport system in Linköping consists of biogas-fuelled buses on 18 different lines transporting 6 million passengers each year. It is tax-financed to 51%. Almost 70% of the passengers travel in peak-hours (7-9 and 14.30-18). The average bus-riding time is 20 minutes and the average travel distance slightly less than 5 km. There is hardly any congestion on the roads in peak-time and there are plenty of bicycle roads between the suburbs and the city-centre. 57% of all trips in Linköping are made by car, 31% by bicycle and 12% by bus (RVU 2001).

5.1 *Basic assumptions of the underlying model of a social surplus maximizing local bus transport authority*

The approach is based on received welfare economics and conventional cost benefit analysis (CBA). The root cause of the divergence between current practices in public transport system design and the optimal design, is the underplay of user costs by the responsible authorities, the county principal, and the ill-considered financial constraints put on public transport in towns. From earlier studies it is indicated where the divergences are most detrimental (Jansson 1980, 1984, 2005, Larsen 1993, Jara-Diaz and Geschwender 2005, 2008 and Ljungberg 2008), so the cost-benefit analysis of which improvements would lead towards optimum did not have to start from scratch. From the mentioned studies it is indicated that general deficiencies of local bus systems are that too large buses are run on too winding routes, and that well-considered peak-load pricing schemes are lacking. The potential of innovative demand management measures like staggered school hours is neither realized. However, before tackling these general problems in the case study of Linköping two special aspects of local public transport that justify some departure from the conventional CBA approach should be pointed out.

Incremental costs and benefits of merit goods

In many small and medium sized towns, the demand base for the public transport system is limited and the total willingness to pay (WTP) of the potential travellers can be insufficient, at least on some routes, to make any public transport service commercially viable. A basic level of public transport is still offered to deserving persons without an income (young and old persons) and/or without other means of transport. The benefit of this basic level is difficult to estimate in a conventional CBA based on the travellers' WTP, and therefore the politically

determined basic public transport services could be regarded as “merit goods”. This means that we will not consider complete discontinuation of any existing bus lines in Linköping.
In most cases, the optimum level of service exceeds the basic level, and the determination of the level of service above the basic level should be based on CBA, where the benefits of all additional travellers are valued by their WTP in the same way as for ordinary goods and services.

The cost of public funds (CPF) is disregarded

The positive impact on the labour market of improved public transport is left out of consideration in this case study. To compensate for this neglect, the cost of public funds (CPF) is disregarded too. The main justification of CPF in CBA of public investments financed by taxes is that the labour market would be further distorted by the required taxation, which will lower the labour supply. However, when travel time and/or the fare for public transport will decrease as a result of an investment in improved local public transport, or a subsidy that makes marginal cost pricing possible in these travel markets, there is an opposite effect on the labour supply which should balance the tax wedge enlargement caused by the tax rise. (See for example Ballard and Fullerton 1992 and Venables 2007)

5.2 *Welfare-raising supply changes: straighter bus routes and smaller bus size*

The public transport supply can be changed in many different ways. It is possible to change mode of transport, route network, number of vehicles and vehicle size. The changes in the bus transport system considered here are selected because they can be assumed to be in the direction of the system optimum in the town of Linköping. The changes and their effects are demonstrated in more detail in Ljungberg (2005, 2007b).

Treating the user costs on an equal footing with the producer costs, it would be profitable in CBA terms to straighten out the existing bus lines in Linköping quite considerably. That would reduce the average travel-time from door to door. The time of a bus round would decrease on most lines, which means that the number of bus rounds can be increased, given the number of buses. The increase in the frequency of service would reduce waiting times at bus stops. The positive effects of shorter waiting time and riding time would more than compensate for the slight lengthening of the average walking distance in the system, which has been calculated on individual data using a geographical information system (GIS) application. The main costs and benefits are shown in Table 3. In some cases where the new bus lines are drawn through residential areas, free of other through traffic, also walking time can be reduced by the line straightening. The encroachment cost that will arise in the residential areas which the new bus lines will cross rather than go around has not been possible to estimate. It is not certain that this is a cost. When a bus line is planned to be drawn through a residential area, some of the residents are protesting, while a planned redrawing of a bus line away from a residential area meets just as strong protests.

Table 3 *Costs and benefits of bus-route straightening in Linköping, Million SEK per year*

TABLE 3 ABOUT HERE

The increase in capacity (the number of bus round trips) that the line straightening brings about will be more than enough to carry the additional demand that will be a consequence of shorter travel-time.

Besides too winding bus routes, another failing from a welfare economic point of view is that too large buses are used in Linköping. The optimal bus size is determined in a balance between the increase in operating costs as a consequence of using more buses of a smaller size and the decrease in waiting-time costs as a result of higher frequency. The main effects are shown in Table 4.

Table 4 *Costs and benefits of reduced bus size in Linköping, Million SEK per year*

TABLE 4 ABOUT HERE

5.3 *Welfare-raising demand management innovations*

The large variation in demand between peak and off-peak is a problem for the capacity utilization. This can be tackled by pricing policy reformation or by other kinds of demand management. The peak within the peak in the morning is hard to handle only by pricing policy. By introducing some variation in the start of the school-day for high-school pupils in Linköping substantial bus transport cost savings would be possible (Ljungberg 2008).

Staggered school hours

At present the majority of the high-school pupils start almost at the same time every day. A staggered school start by only half an hour would reduce demand considerably for the most demanded departures on several bus-lines. The main disadvantage would be that the pupils would have to wake up earlier some mornings. The costs of this sacrifice have been estimated by the contingent valuation method (CVM). The CVM-study is based on a questionnaire to the pupils asking for their compensation requirements for accepting the change. Asking for their WTP for being spared this inconvenience would be pointless, since they have no income of their own. The estimated main effects are shown in Table 5.

There are some pupils (15%) that would prefer a staggered school start, but the benefit for these pupils has not been estimated. Interviews with teachers and principals on the schools show mainly a positive attitude towards a staggered school start. It will cause problems only for some teachers, and put some more effort for the principals to schedule the classes.

Table 5 *Costs and benefits of a staggered high-school start, Milion SEK per ear*

TABLE 5 ABOUT HERE

Peak-load pricing

An optimal price structure implies first price differentiation between peak and off-peak hours. Travel direction also matters, as well as where on the line the trip is made. The optimal fare is at its highest in peak-hours through "the critical section", where the expected passenger flow is at a maximum. The critical section can be relatively short.

The price-relevant cost has two components: the cost of occupying space on the bus, and the time cost caused by boarding/alighting. Outside the critical section the optimal fare, even in peak-hours, only includes a boarding/alighting charge. The tariff of optimal bus fares could for simplicity be confined to just three different fares as given in Table 6. The underlying assumptions for these results can be found in Jansson and Ljungberg (2007), and is based on the tradition started by Mohring (1972) and developed further by Turvey and Mohring (1975), Jansson (1979, 1984). Other works in this tradition are Larsen (1983), Jansson K (1993), Jansson (1997), Pedersen (2003) and Jara-Diaz and Gschwender (2003, 2008).

Table 6 *Summary of the optimal tariff of bus fares*

TABLE 6 ABOUT HERE

The peak fare in the critical section is the sum of the applicable occupancy charge and boarding/alighting charge. The two terms within the bracket of the expression for the occupancy charge are recognized as the cost of a peak-only bus (C_{peak}) per bus round (n), and the Mohring effect of another bus round, which is a negative cost. The net of these two items is transformed to a cost per passenger through the critical section by the factor before the bracket. The composition of this factor is interesting in so far as it shows that the occupancy charge is quite sensitive to route distance (D) and the bus size (S), which both can vary in a wide range. The cruising speed (H) is of less consequence in this connection, since it is much less variable in practice where an already high level of bus-priority at traffic-lights applies.

The first term within the second bracket in the expression for the peak fare in the critical section is again the cost of a peak-only bus per bus round. The second term stands for the time costs of the passengers on the bus per hour. The sum of these two costs is transformed to a cost per boarding passenger by the factor before that bracket, t, representing the boarding time per passenger (in hours).

The peak fare outside the critical section includes just the last-mentioned boarding/alighting charge, and the off-peak fare is given by an expression for a similar cost, where the main difference is that the number of buses by definition does not include the peak-only buses, but only the basic supply of all-day buses (N_{basic}). A numerical example of optimal fares is given in Table 7

Table 7 *Example of optimal fares on a main bus line of 9 kilometres (one leg) in Linköping, SEK per trip*

TABLE 7 ABOUT HERE

The optimal peak fare in the critical section is positively related to the length of a bus line. It is only travel in the critical section which is crucial, irrespective of how long a particular trip is, but the longer the line is, the higher the optimal fare for traversing the critical section will be. Therefore, comparing trips on lines of different length, the optimal fare will on average be higher, the longer the line is.

The off-peak fare is very low, so low in fact that fare collection does not seem worthwhile. Offering the off-peak service free of charge would halve, at least, the price-relevant cost – the boarding/alighting time (t) would go down – and definitely take away the efficiency reason for pricing.

In order to calculate the consequences of a zero off-peak fare, it is necessary to estimate the number of additional off-peak passengers that will be induced. The expected increase in passengers is based on a Stated Preference survey carried out in Linköping, combined with relevant demand elasticity studies found in the literature, and most decisively on results from real zero fare experiences. The results from Linköping indicate a very high expected increase in passengers as a result of a zero off-peak fare in combination with the required capacity improvements (Ljungberg 2007a, Ljungberg 2007b). The number of off-peak passengers in Linköping can be expected to increase by 150% if free off-peak bus transport is offered. 20% of the new trips will be diverted from car, 21% from peak period bus, 33% from cycling and walking, and consequently 26% will be newly generated trips. This is in line with Swedish experiences of small towns where a 100% increase in passengers as a consequence of an all-day zero fare is reported. There are other examples of a very large increase in the number of passengers as a result of a zero fare in combination with a greatly improved public transport system (Hasselt in Belgium). The large increase in the off-peak capacity requirement can be met simply by using all buses also in off-peak.

Peak demand will decrease by 15%. The corresponding decrease in peak capacity is brought about by a slightly reduced number of buses used in the peak periods. Table 8 shows the benefits and costs of a zero off-peak fare in Linköping.

Table 8 *Costs and benefits of a zero off-peak fare in Linköping, Million SEK per year*

TABLE 8 ABOUT HERE

The decrease in waiting-time costs is the net of the increase for the remaining passengers traveling in peak and the decrease for existing passengers travelling in off-peak. The net benefit for new passengers in off-peak is quite large as a result of the drastic decrease in the generalized cost, due to the zero fare and the increase in off-peak frequency of services.

Besides the main components, table 8 also includes the external benefit from the reduction in exhaust emissions and accident costs due to less car traffic. These external benefits (and reduced road congestion) would be very important in large cities, but are relatively small in a town like Linköping without congestion problems on the roads.

In this connection it should be mentioned that in particular in large US cities, problems of joy riders, inebriate adults and homeless people on the buses increased with zero fares, which repelled regular bus passengers (Perone 2002). This has not happened in towns in Sweden. However, some problems of vandalism and joy riding do appear at night time, and consequently zero fare on night services is not recommended.

5.5 *Total net benefits and the financial result of the proposal*

Table 9 gives the initial position for the public transport system of Linköping, as well as the predicted changes resulting from a reorientation of public transport policy towards net social benefit maximization including all above mentioned policy changes.

Table 9 *Main characteristics before and after the proposed reorientation of public transport policy in Linköping*

TABLE 9 ABOUT HERE

Changing from the present system to the proposed system will give rise to a net social benefit of 30 million SEK per year. Converted to US dollars it amounts to $5 millions, or $40 annually per inhabitant in Linköping. The financial result, which has not been taken into account in the previous cost-benefit analysis, is an annual deficit of 17 million SEK.

The main group of winners are the off-peak travellers, both the original 1.9 million off-peak passengers who get a GC reduction of 16.6 SEK per trip, and those 3.4 million new off-peak passengers, which valued by the rule of half gets a benefit of 8 SEK per trip. The losers will be all those who do not travel by bus in off-peak, but the loss per person will be minute. Peak travellers by bus will be worse off by 1.5 SEK per trip and tax payers not travelling by bus at all will be worse of by 0.75 SEK per day.

6. Conclusions

The chapter title puts this question: Local public transport in towns – inevitably on the decline? The answer we have come up with in this chapter is that by regarding a basic supply of local bus services as merit goods, and providing a level of service above the basic minimum level to the extent that the incremental benefits exceed the incremental costs, and pursuing an optimal peak-load pricing policy would break the declining trend and evoke a virtuous spiral in the case study town of Linköping. The pricing policy would involve zero-fares in off-peak, which would raise off-peak demand so much that the same frequency of service should apply all day.

6.1 *Future development*

As seen in Table 9 above, an one-off increase in total bus travel of 42% would occur as a result of the proposed policy changes. That could very well trigger a new virtuous circle. If a sustained positive development would arise depends, however, on some other factors.

Three significant exogenous factors which have been considered in the previous analysis are, as shown in Table 2 above, the female employment rate, the rate of car ownership, and the share of the population living in the outer suburbs. The base scenario is to assume that all three factors will develop in the same way as in the past 25 years (that is, the period of the vicious spiral). This means first that the rate of female employment, which was such a strong positive force in the period of the virtuous spiral, is assumed to be constant as it has been in the past 25 years. Secondly the rate of car ownership will increase by 0.8% per year. Thirdly the share of the population living in the outer suburbs has actually decreased a little since the beginning of the 1980s. However, this is due to the isolated case of closing down a regiment occupying quite a central area in town, which then was used for new dwelling-houses. Currently there are other efforts to fill in empty spaces by house-building, but the outer suburbs are expanding, too. All in all, it can be assumed that the spatial structure of the population in Linköping will remain the same for some time. On these assumptions it follows that, if the primary policy variable considered, that is the generalized cost per bus trip, which has been on the increase during the preceding period of the vicious spiral, would stop to increase and stay at the lower level obtained by the proposed reforms, only the continued growth of car ownership, would be a negative force.

Just to stay at the lower GC level attained by the policy reorientation considered would be an achievement. The public transport productivity growth has not been very impressive in the last few decades, well below the productivity growth in manufacturing industry. The public transport producer cost development seems badly hit by Baumol's cost-disease. However, the resultant increase in demand from the positive "shock" of a GC reduction of 23%, and the new way of looking at local public transport, where the users of the services are brought into the focus, would create new conditions for a positive development. Who knows which innovations will be round the corner in this new situation?

6.2 *A final reservation: the growing health consciousness*

We should not finish on this note of optimism without mentioning an aspect for the future of increasing importance: the health aspect. Travel by public transport is healthier than travel by car, because bus and commuter train trips often involve a certain amount of walking or bicycling to/from stops and stations. Still healthier, however, are complete travel by foot or bicycle, provided that the risk of being hit by a car is minimal. In the health-conscious society of today it seems like attitudes and preferences for short-distance modes of travel are changing. To probe into the future to see what may come if the health-consciousness and consequent behaviour will spread in the population at large, a questionnaire was directed to a particular category of people who every day can see the ill-effects of obesity and heart-diseases caused by (among other things) lack of exercise. The regional hospital in Linköping is one of the largest employers in town. The hospital is fairly centrally located so no one living in the built-up area of Linköping would have more than 10 kilometres for his/her travel to work at the hospital.

A questionnaire concerning the travel to work habits of hospital employees was prepared by a collaborator in the project working at the hospital, and put into the pigeonholes of a sample of 61 fellow-workers, 46 women and 15 men. All answered the questionnaire, and in total 451 work trips were recorded. Of these 73 per cent were made by employers living in town. There was a big difference in travel habits between the majority who lived in the town and those living out of town in the country or in other towns and villages. Among the latter, 60 per cent of the work trips were made by car, 40 per cent by public transport, and consequently no trips were made by foot or bicycle. In table 10 the model split for trips made by the hospital employees living in the town are given, and as seen, their travel habits are completely different from those living out of town.

Table 10 *Modal split for travel to work at Linköping Hospital in April 2006 by employees living in the town*

TABLE 10 ABOUT HERE

It should be emphasized again: this sample is not representative of Linköping. It consists of health-conscious employees of a big hospital of university status, where the “Heart centre” is a famous cluster of clinics. Springtime is neither an average season so far as travel to work is concerned, and the four days during which the investigation was carried out had fair weather. However, the share of walk and bicycle is not very much lower even during winter, although we have no figures to substantiate this general impression.

It is often pointed out that, when various errands have to be carried out on the way between home and work, the car is the preferred mode of transport. It was found in the sub-category of work trips involving also leaving/fetching children at nurseries that the bicycle share still was 57 per cent.

What this result tells us for the future, we cannot yet say, but it confirms a common view among public transport planners and operators in towns that the bicycle is already a more difficult competitor in the local transport market than the car.

REFERENCES

Balcombe, R., Mackett, R., Paully, N., Preston, J., Shires, J., Titheridge, H., Wardman, M. and White, P. (2004). *The Demand for Public Transport: a Practical Guide*. TRL report, TRL593.

Ballard, C. and Fullerton, D. (1992). Distortionary Taxes and the Provision of Public Goods. *Journal of Economic Perspectives*, Vol 6, No 3, 117-131.

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy,* 15, 73-80.

Curtis, C. (2008). Planning for sustainable accessibility: The implementation challenge. *Transport Policy,* 15, 104-112.

Goldman, T. and Gorham, R. (2007). Sustainable urban transport: Four innovative directions. *Technology In Society,* 28, 261-273.

Goodwin P.B. (1992). A review of new demand elasticities with special reference to short and long run effects of price changes. *Journal of Transport Economics and Policy,* 26, 155-169.

Greene W.H. (2003). *Econometric analysis*. 5th ed. Prentice Hall.

Holmgren, J. (2007). Meta-Analysis of Public Transport Demand. *Transportation Research: Part A: Policy and Practice*, 41:1021-1035.

Holmgren, J. (2008). *Studies in local public transport demand*, PhD-thesis, forthcoming.

Jansson, JO. (1979). Marginal Cost Pricing of scheduled Transport Services. *Journal of Transport Economics and Policy*, 13, 268-294.

Jansson, JO. (1980). A simple bus line model for optimisation of service frequency and bus size. *Journal of Transport Economics and Policy,* 14, 53-80.

Jansson, JO. (1984). *Transport System Optimization and Pricing*. John Wiley & Sons.

Jansson, JO. (1997). Theory and practice of transport infrastructure and public transport pricing. In Nash, C. and de Rus, G. (Ed), *Recent Developments in Transport Economics*. Gower, Aldershot.

Jansson, JO. (2005). *Bus transport system optimization and pricing.* 9th Conference on Competition and Ownership in Land Transport (Thredbo9), Lisbon, Portugal.

Jansson, JO. and Ljungberg, A. (2007). Level and structure of optimal bus fares. In Macario, R., Viegas, J. and Hensher, D. (Ed), *Competition and Ownership in Land Passenger Transport- Selected Papers from the 9th International Conference (Thredbo9), Lisbon, September 2005*. Elsevier.

Jansson, K. (1993). Optimal Public Transport Price and Service Frequency. *Journal of Transport Economics and Policy,* 27, 33-50.

Jansson, L. (2006). *Resvaneundersökning*. Enkätuppgift I ALF 1 kurs vt 2006.

Jara-Diaz, S. R. and Gschwender, A. (2003). Towards a General Microeconomic Model for the Operation of Public Transport. *Transport Review,* 23, 453-469.

Jara-Diaz, S. R. and Gschwender, A. (2005). Making Pricing Work in Public Transport Provision. Chapter 26 in *Handbook of Transport Strategy, Policy and Institutions.* Edited by K.J. Button and D. A. Hensher, Elsevier Ltd, 447-459.

Jara-Diaz, S. R. and Gschwender, A. (2008). The effect of financial constraints on the optimal design of public transport services. *Transportation,* forthcoming.

Larsen, O I. (1983). Marginal Cost Pricing of Scheduled Transport Services: Notes and Comments. *Journal of Transport Economics and Policy,* 17, 315-317.

Larsen, O I. (1993). *Samfunnsnytte av tiskudd til kollektivtrafikk.* Transportökonomisk Institutt, TÖI rapport 208/1993, Oslo.

Ljungberg, A. (2005) *Using Geographic Information System (GIS) doing CBA on new bus-route systems – an empirical example of the city of Linköping.* 9th Conference on Competition and Ownership in Land Transport (Thredbo9), Lisbon, Portugal

Ljungberg, A. (2007a). Optimal bus transport financing – a cost -benefit analysis of zero fares policies in urban bus transport. In Macario, R., Viegas, J. and Hensher, D. (Ed), *Competition and Ownership in Land Passenger Transport- Selected Papers from the 9th International Conference (Thredbo 9), Lisbon, September 2005*. Elsevier.

Ljungberg, A. (2007b). *Lokal kollektivtrafik på samhällsekonomisk grundval*. Diss. IEI, Linköping University. http://www.ep.liu.se/abstract.xsql?dbid=10095

Ljungberg, A. (2008). Staggered school hours to spread peak demand for public transport – benefits and costs, *International Journal of Transport Economics and Policy,* accepted for publication.

Mohring, H. (1972). Optimization and Scale Economies in Urban Bus Transportation. *American Economic Review, 62, 591-604.*

Ortuzar, J. and Willumsen, L. (2001). *Modelling transport*, 3rd ed. Wiley

Oum T.H., Waters W.G. and Yong J.S. (1992). Concepts of price elasticities of transport demand and recent empirical estimates. *Journal of Transport Economics and Policy*, 26, 139-154.

Pederson, P. (2003). On the Optimal Fare Policies in Urban Transportation. *Transportation Research B,* 37, 423-435.

Perone, J S. (2002). *Advantages and Disadvantages of Fare-Free Transit Policy*. National Centre for Transportation Research, Tampa, Florida.

RVU. (2001). *Resvaneundersökning*. Linköpings kommun.

SLTF. (2002). *Public transport in Sweden – co-ordination and competition.* SLTF, Stockholm.

Turvey, R. and Mohring, H. (1975). Optimal Bus Fares. *Journal of Transport Economics and Policy,* 9, 280-286.

Venables, A J. (2007). Evaluating Urban Transport Improvements, Cost-Benefit Analysis in the Presence of Agglomeration and Income Taxation. *Journal of Transport Economics and Policy*, vol 41, 2, 173-188.

Webster F.V. and Bly P.H. (1980). *The demand for public transport*. Report of the international collaborative study of the factors affecting public transport patronage.

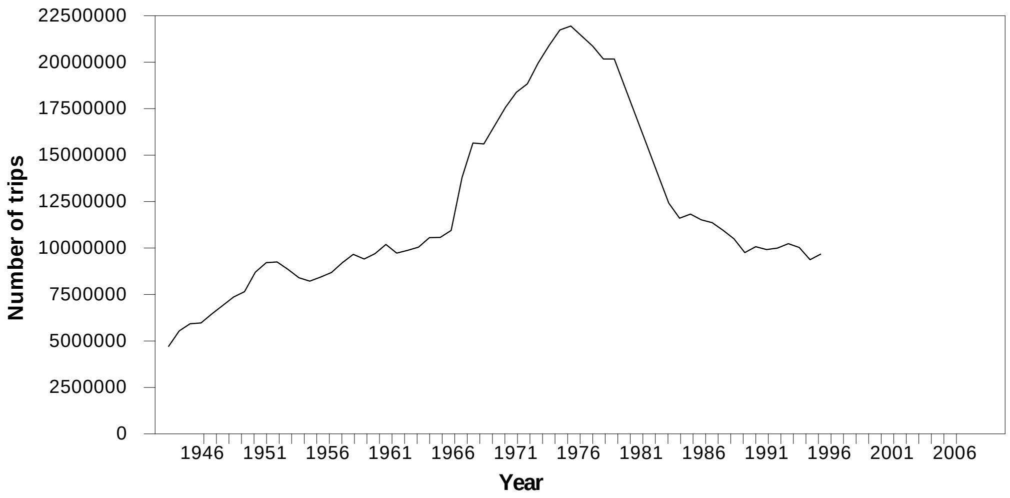

Figure 1 *Post-war development of public transport in Linköping*

Table 1 *Result of regression analysis of the development of bus trips per person in Linköping 1946-2006*

Variable	**Coeff**	**Std Error**	**T-stat**	**Signif**
Constant	-0,0087	0,015	-0,57	0,57
Fare (P)	-0,25	0,11	-2,36	0,022
$Dummy_{fare}$	0,02	0,009	2,36	0,021
Vkm/km^2 (v)	0,44	0,14	3,25	0,002
Female labour force participation (FE)	0,3	0,073	4,06	0,0002
Car ownership (C)	-0,67	0,32	-2,12	0,039
Share of population in outer areas (c3)	1,6	0,39	4,12	0,00013
R2-adj	0,42			
D-W	1,77			

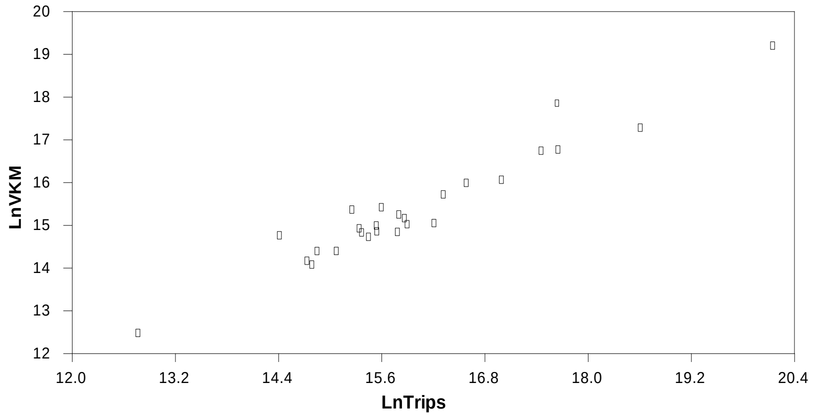

Figure 2 *Plot of total public transport vehicle-kilometres against total trips by public transport (logarithmic scale)*

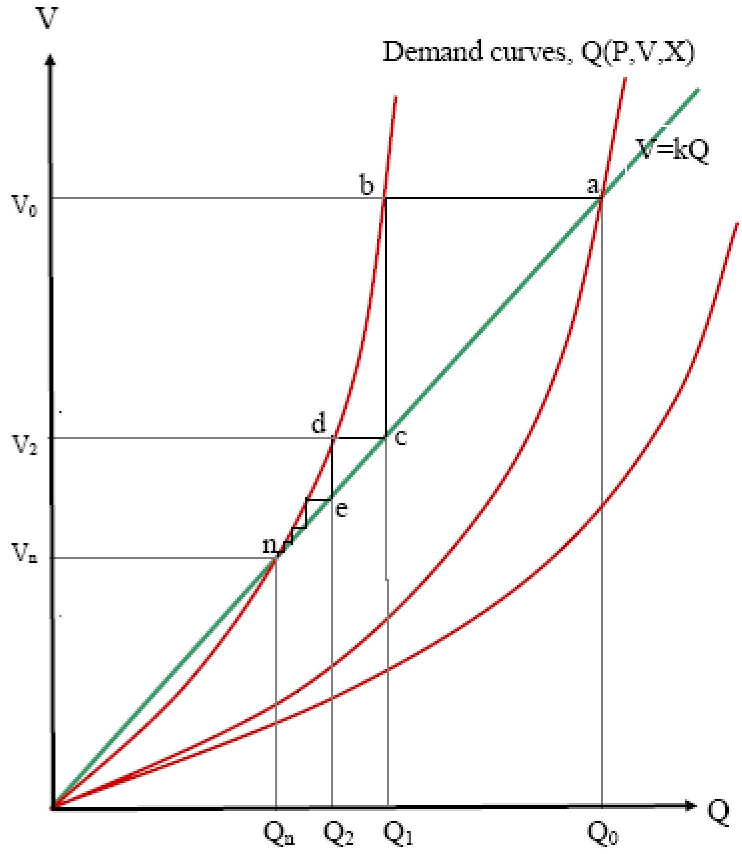

Figure 3 *The path from one market equilibrium (a) to another (n)*

Table 2 *Short-run and total adjustment bus travel demand elasticities for the town of Linköping*

Variable	**Short-run**	**Total adjustment**
Fare (before 1977)	–0,25	–0,45
Fare (after 1977)	–0,23	–0,41
Female labor participation	0,3	0,54
Car ownership	–0,67	–1,2
Share of population in outer areas	1,6	2,86

Table 3 *Costs and benefits of bus-route straightening in Linköping, Million SEK per year*

Effect	**Benefit**	**Cost**
Increased walking-time for existing passengers		5.5
Shorter waiting-time for existing passengers	7	
Shorter riding-time for existing passengers	13	
Benefit of new passengers	6	
Investments in bus-ways and bus-stops		2.5
Sum	**26**	**8**

1$ = 6 SEK

Table 4 *Costs and benefits of reduced bus size in Linköping, Million SEK per year*

Effect	**Benefit**	**Cost**
Shorter waiting-time for existing passengers	6.3	
Shorter riding-time for existing passengers	0.2	
Benefit of new passengers	1.8	
Increased cost for the operator		5.0
Sum	**8**	**5**

1$ = 6 SEK

Table 5 *Costs and benefits of a staggered high-school start, Million SEK per ear*

Effect	**Benefit**	**Cost**
Reduced cost for the operator	8	
Increased cost for the pupils		5.6
Sum	**8**	**6**

1$ = 6 SEK

Table 6 *Summary of the optimal tariff of bus fares*

Peak fare through the critical section	$\frac{D}{SH}\left(\frac{C_{peak}}{n}+Q_{peak}\frac{\partial AC_{user}}{\partial N}\right)+t\left(\frac{C_{peak}}{n}+\frac{Q_{peak}}{N}AC_{ride}\right)$
Peak fare outside the critical section	$t\left(\frac{C_{peak}}{n}+\frac{Q_{peak}}{N}AC_{ride}\right)$
Off-peak fare	$\frac{tR}{N_{basic}-tR}AC_{user}$

D = Distance (two legs)
S = Number of seats of a bus
H = Bus cruising speed (including time for stopping and starting)
Q_{peak} = Total number of passengers per peak hour
R = Total number of passengers per off-peak hour
N = Total number of buses in operation
C_{peak} = Day cost of a peak-only bus
n = Number of bus rounds (per bus) in the peak periods
t = Average time per trip for boarding/alighting

Table 7 *Example of optimal fares on a main bus line of 9 kilometres (one leg) in Linköping, SEK per trip*

When and where	**Occupancy charge**	**Boarding/alighting charge**	**Total fare**
Peak hours in the critical section	13	2	15
Peak hours outside the critical section		2	2
Off-peak		1	1

Table 8 *Costs and benefits of a zero off-peak fare in Linköping, Milion SEK per year*

Effect	**Benefit**	**Cost**
Decreased waiting-time costs for existing passengers	0.5	
Net benefit for new passengers	9	
Increased cost for the operator		3
Reduced exhaust emissions due to change from car	0.5	
Reduced accident costs due to change from car	0.1	
Sum	**10**	**3**

1$ = 6 SEK

Table 9 *Main characteristics before and after the proposed reorientation of public transport policy in Linköping*

Main characteristics	**Present system**	**Proposed system**
Total number of passengers	6 million	8.5 million
Total number of peak pass. (7-9, 14.30-18)	4.1 million (2820/hour)	3.2 million (2200/hour)
Total number of off-peak passengers	1.9 million (685/hour)	5.3 million (1910/hour)
Total length of bus-lines	116 km	96 km
Number of peak-only buses Max load = 106 (45 seats) Max load = 77 (36 seats)	 10 10	 0 0
Number of all-day buses Max load = 106 (45 seats) Max load = 77 (36 seats) Max load = 63 (30 seats)	 18 18 0	 0 18 34
Total bus company cost per annum	124 million SEK	128 million SEK
Total revenue per annum	61 million SEK	47 million SEK
Producer cost per passenger	20.7 SEK/passenger	15.1 SEK/passenger
Peak fare	10.2 SEK/passenger	14.8 SEK/passenger
Off-peak fare	10.2 SEK/passenger	0 SEK/passenger
Generalized cost components in Peak: Fare Walk Wait Ride **Total**	SEK/passenger 10.2 4.1 9.5 14 **37.8**	SEK/pass. change 14.8 (45%) 5.1 (24%) 8.6 (–10%) 10.8 (–23%) **39.3 (4%)**
Generalized cost components in Off-Peak: Fare Walk Wait Ride **Total**	SEK/passenger 10.2 4.1 12.7 14 **41.0**	SEK/pass. change 0 (–100%) 5.1 (24%) 8.6 (–33%) 10.8 (–23%) **24.4 (–40%)**
Average generalized cost (fare + walk + wait + ride)	38.8 SEK/passenger (10.2 + 4.1 + 10.5 + 14)	30.0 SEK/pass (-23%) (5.5 + 5.1 + 8.6 + 10.8)

Table 10 *Modal split for travel to work at Linköping Hospital in April 2006 by employees living in the town*

Mode of travel	Percentage share of total trips	
	have a car at disposal	have no car at disposal
Walk	10	12
Bicycle	76	77
Car driver	12	0
Car passenger	0	4
Bus	2	7
	100	100

Source: Jansson L (2006)