MODE SHIFT TO ARLANDA AIRPORT FOR SUSTAINABLE DEVELOPMENT

THREDBO 7

Competition and ownership in land passenger transport
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1 Background and introduction

The Swedish Institute for Transport and Comunications Analysis (SIKA), The Swedish National Road Authority (Vägverket) and the Swedish Rail Track Authority (Banverket) have been examining the possible role of objective-oriented planning. The author of this paper and Svensk Trafikkompetens AB, VBB VIAK and Henrik Swahn were given the task to test this methodology for the case ground transport to Arlanda airport in Stockholm.

The prerequisite was the assumption that emissions related to ground transport to Arlanda airport and to the flight movements at the airport in the year 2010, should be kept at the 1990 level without intervening the development of air traffic. The air traffic has been foreseen to increase by some 45% between 1990 and 2010, but it was assumed that the emissions per passenger might be reduced by around 30%.

The task was thus to assess the possibilities to shift choice of mode for ground transport to the airport in order to fulfil the objective of keeping the emissions at the 1990 level. Since nitrogen oxide had been reduced by catalytic cleaning it became obvious that the binding constraint concerned the emissions of carbon dioxide. The target of the analysis thus became to reduce the annual carbon dioxide emissions by around 36 000 tons, given that aircrafts reduce their emissions around 30% per seat kilometre till the year 2010.

This paper describes the possibilities to reduce the carbon dioxide emissions by use of passenger transport measures only. In addition goods transport measures can be undertaken, which also have been analysed in the full Swedish report.

Of course the prerequisite of this work, to reduce carbon dioxide emissions from ground transport only and leave air transport untouched does not seem very realistic. But please notice that the work was a methodological one rather than real. In a serious work one should investigate the benefits and costs of reductions of the whole transport sector in Sweden, or, if possible in the world.

The test character of the analysis is, however, useful from methodological point of view. To have a specific objective as the starting point and search for the less costly way to obtain the objective may be worth considering in many cases, especially since politicians often focus on a specific objective.

This work is also useful from another point of view. It illustrates the effects of various measures to improve the environment, in terms of mode choice, emissions, passengers' benefits and costs, public sector finances and net social surplus. As everybody could expect, the most efficient measure is car charges. The analysis also illustrates that other measures related to public transport can complement, but also that some public transport measures are less brilliant.

2 Points of departure

The VIPS assignment model was used for calculation of mode choice, revenues, costs and effects on passengers in terms of price and travel time components. Some characteristics of the VIPS model are found in the appendix.

The information on demand for ground transport to/from Arlanda is taken from a good travel demand survey carried out by the Swedish National Air Transport authority (Luftfartsverket). It comprises information about modes chosen, including transfers between modes, for origin areas within and outside the Stockholm county boundary. This excellent information gave the opportunity to separately analyse competition between travel opportunities for the following segmentation according to available modes. All in all 14 passenger groups were analysed separately.

Table 2.1 Segmentation according to available modes

Trip origin within Stockholm county				
Business living in Stockholm	*Business living outside Stockholm*	*Private living in Stockholm*	*Private living outside Stockholm*	*Working at airport*
1 SL-cash Car parked Car ift Taxi	3 SL-cash Car lift Taxi	5 SL-cash Car parked Car lift Taxi	9 SL-cash Car lift Taxi	11 SL-cash Car parked
	4 SL-cash Taxi		10 SL-cash Taxi	12 SL-card
2 SL-cash Taxi		6 SL-cash Taxi		
Trip origin outside Stockholm county		7 SL-card Car parked Car lift Taxi		
Business				
13 Public transport Car, taxi		8 SL-card Taxi		
Private				
14 Public transport Car				

The travel alternatives thus comprised not only direct travel by ordinary public transport, national SJ trains, the new rail line Arlanda Express, the airport coaches taxi and private car, but also the combinations of taxi and private car (self-drive and lift), to the various public transport modes.

The measures investigated in order to shift passengers to less polluting modes were the following:

- Extension of an existing commuter rail line by some 5 km to the airport, (Commuter train)

- Improved and subsidised public transport. This alternative meant more rail lines, more airport coach lines, both with increased service frequency, and subsidies of around 40% (Public transport),

- Car zone charge at the airport. Here both private cars and taxis were assumed to be charged a substantial amount to drive or park within a zone around the airport (Car charges),

- A combination of the three first measures (Combination).

3 Results

3.1 Alternative - Commuter train extension

3.1.1 Mode shift

The table below shows the calculated mode shift due to extension of the commuter line.

Table 3.1.1 Calculated mode shift

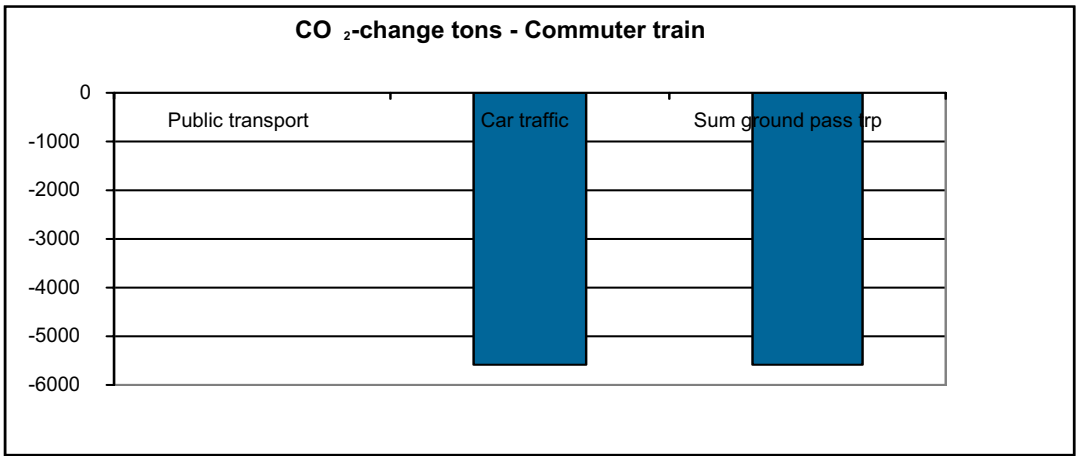
	Change with measure, absolute and in percentage terms							
	Passenger kms, millions/year				%	%	%	%
	Business	Private	Work	Sum	Business	Private	Work	Sum
SL	2	86	22	111	37%	234%	49%	125%
SLbus to Arlanda	0	-3	-3	-6	-47%	-59%	-27%	-36%
Commuter train	3	105	26	134	222%	626%	396%	545%
Airport coach Stockholm	-1	-21	-17	-38	-3%	-31%	-54%	-29%
Airport coach Uppsala	0	0	0	0	-5%	0%	0%	0%
Intarnal bus Arlanda	0	0	0	0		-8%	-2%	-3%
SJ-train	-1	11	0	10	-6%	7%		5%
TIM-train	1	1	0	2	36%	9%		15%
Arlanda Express	-1	-22	0	-23	-1%	-56%	0%	-24%
Other buses	0	1	0	1	0%	1%	0%	1%
Sum public transport	1	72	6	79	1%	23%	10%	16%
Car parked	0	-21	-1	-22	0%	-8%	-1%	-4%
Car lift	0	-24	0	-24	-1%	-20%		-20%
Taxi	0	-9	0	-9	0%	-39%		-5%
Sum car and taxi	0	-53	-1	-55	0%	-13%	-1%	-6%
Sum passenger kms	0	19	5	24	0%	3%	3%	2%

In total this measure is calculated to increase public transport by 16% and reduce car and taxi trips by 6%. However, the demand for airport coaches and Arlanda Express, a less wanted redistribution result when the aim is to increase the public transport share

3.1.2 Emissions

The diagram below shows the calculated reduction of carbon dioxide if the commuter train line is extended. Apparently only about 15% of the target 36 000 ton would be achieved with this measure according to the calculations.

Table 3.1.2 Calculated change of carbon dioxide emissions


CO ₂-change tons - Commuter train
0
-1000
-2000
-3000
-4000
-5000
-6000
Public transport
Car traffic
Sum ground pass trp

3.1.3 The passengers

The table below shows the calculated changes of generalised cost and consumer surplus for various passenger groups.

Table 3.1.3 Change of passengers' benefits and costs

Measure 2010 compared with Reference 2010	**Air passengers to/from Arlanda**				**Staff**	**Sum**
	Business start in Stockholm	Private start in Stockholm	Business start outside Stockholm	Business start outside Stockholm	working at Arlanda	
No. of trips per year, thousands	6 764	7 085	1 309	2 772	5 921	23 849
ΔGeneralised cost per trip, SEK	0,70	8,72	-0,06	2,60	1,28	
of which time, SEK	*0,04*	*-8,88*	*-0,13*	*-2,61*	*0,23*	
of which price, SEK	*0,66*	*17,60*	*0,07*	*5,21*	*1,05*	
ΔGeneralised cost per trip, %	0,11	3,20	0,00	0,30	2,01	
ΔConsumer surplus, MSEK/year	5	62	0	7	8	81
of which time, MSEK/year	*0*	*-63*	*0*	*-7*	*1*	*-69*
of which price, MSEK/year	*4*	*125*	*0*	*14*	*6*	*150*

Basically the gain is mainly composed of money saving.

3.1.4 Welfare

The table below summarises the benefits and costs of the measure.

Table 3.1.4 Summary of welfare changes

Benefits and costs	MSEK/year
Consumer surplus	81
of which time	*-69*
of which price	*150*
Private sector finances	-97
Cost adjustment	-20
Net public surplus	-30
Excess burden	-9
External effects	3
Sum	-73

Extension of the commuter train line does not seem to be socially beneficial. The cost per ton reduced emissions would be 13 SEK.

3.2 Alternative - Better and cheaper public transport

3.2.1 Mode shift

The table below shows the calculated mode shift due to extension of better and subsidised public transport.

Table 3.2.1 Calculated mode shift

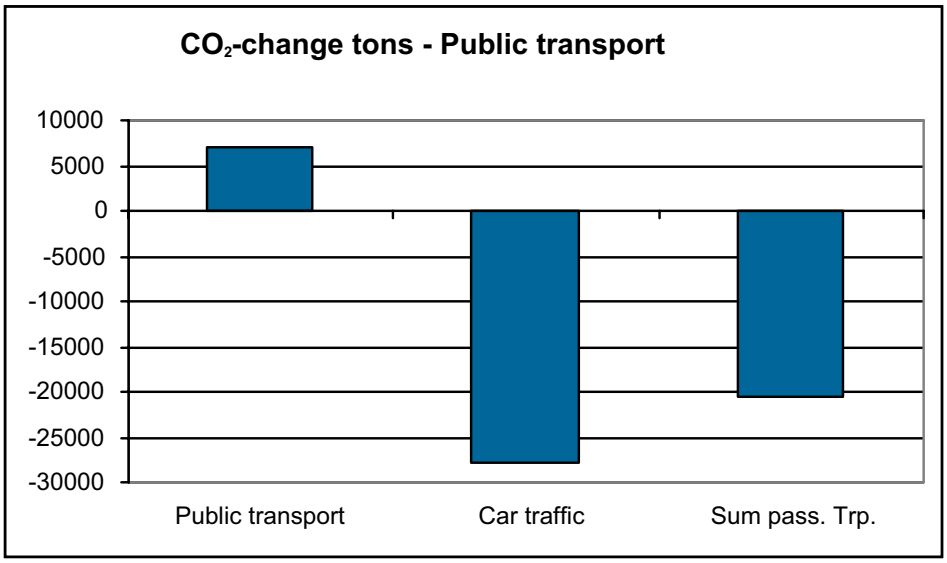
	Change with measure, absolute and in percentage terms							
	Passenger kms, millions/year				%	%	%	%
	Business	Private	Work	Sum	Business	Private	Work	Sum
SL	1	18	-1	18	19%	48%	-1%	20%
SLbus to Arlanda	0	-2	-2	-4	-34%	-46%	-16%	-24%
Commuter train	0	-5	-3	-8	14%	-31%	-52%	-34%
Airport coach Stockholm	3	106	9	119	10%	161%	30%	90%
Airport coach Uppsala	0	14	0	14	14%	144%	0%	78%
Intarnal bus Arlanda	0	-1	0	-1		-34%	-7%	-13%
SJ-train	1	4	0	5	6%	2%		3%
TIM-train	10	52	0	62	332%	427%		408%
Arlanda Express	61	-27	0	34	113%	-68%	0%	36%
Other buses	0	4	0	4	15%	6%	0%	6%
Sum public transport	76	141	4	221	67%	45%	6%	46%
Car parked	-18	-63	-6	-87	-10%	-23%	-5%	-16%
Car lift	1	-73	0	-72	344%	-60%		-59%
Taxi	-63	-18	0	-80	-37%	-78%		-42%
Sum car and taxi	-80	-153	-6	-239	-23%	-37%	-5%	-27%
Sum passenger kms	-3	-12	-2	-17	-1%	-2%	-1%	-1%

In total this measure is calculated to increase public transport by 46% and reduce car and taxi trips by 27%.

3.2.2 Emissions

The diagram below shows the calculated reduction of carbon dioxide if public transport is improved and subsidised. According to the calculation 21 000 reduction, 58%, of the target 36 000 ton would be achieved with this measure.

Table 3.2.2 Calculated change of carbon dioxide emissions


CO2-change tons - Public transport
10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
Public transport
Car traffic
Sum pass. Trp.

3.2.3 The passengers

The table below shows the calculated changes of generalised cost and consumer surplus for various passenger groups.

Table 3.2.3 Change of passengers' benefits and costs

Measure 2010 compared with Reference 2010	**Air passengers to/from Arlanda**				**Staff**	**Sum**
	Business start in Stockholm	Private start in Stockholm	Business start outside Stockholm	Business start outside Stockholm	working at Arlanda	
No. of trips per year, thousands	6 764	7 085	1 309	2 772	5 921	23 849
ΔGeneralised cost per trip, SEK	27,24	24,53	5,54	16,08	2,04	
of which time, SEK	*-17,14*	*6,18*	*6,83*	*11,24*	*1,87*	
of which price, SEK	*44,38*	*18,35*	*-1,29*	*4,84*	*0,17*	
ΔGeneralised cost per trip, %	4,43	9,01	0,35	1,83	3,20	
ΔConsumer surplus, MSEK/year	184	174	7	45	12	422
of which time, MSEK/year	*-116*	*44*	*9*	*31*	*11*	*-21*
of which price, MSEK/year	*300*	*130*	*-2*	*13*	*1*	*443*

Now three passenger groups would benefit both in terms of time and money.

3.2.4 Welfare

The table below summarises the benefits and costs of the measure.

Table 3.2.4 Summary of welfare changes

Benefits and costs	MSEK/year
Consumer surplus	422
of which time	*-21*
of which price	*443*
Private sector finances	0
Cost adjustment	-75
Net public surplus	-277
Excess burden	-83
External effects	6
Sum	-7

Improved and subsidised public transport is virtually neutral from welfare point of view. The cost per ton reduced emissions would thus be almost zero.

3.3 Alternative - Car charges

3.3.1 Mode shift

The table below shows the calculated mode shift due to a zone car charge around Arlanda airport.

Table 3.3.1 Calculated mode shift

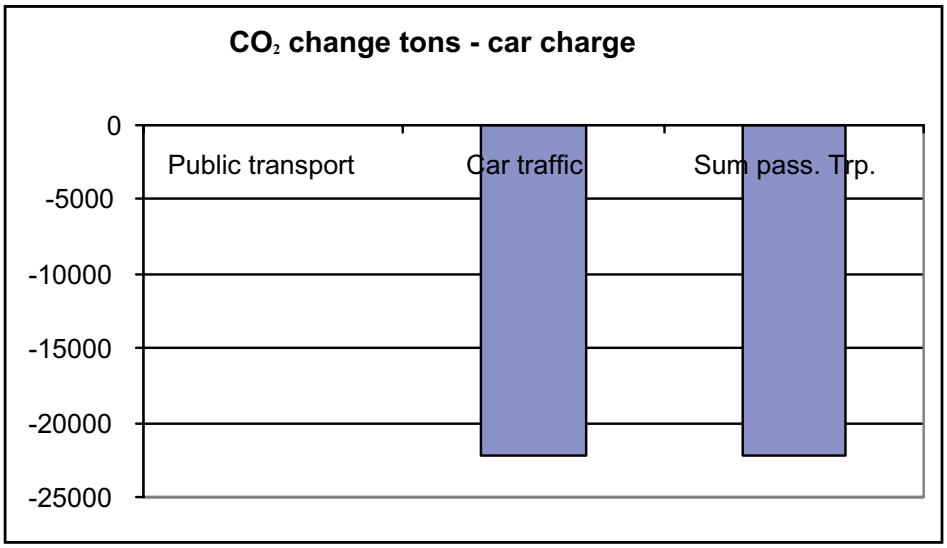
	Change with measure, absolute and in percentage terms							
	Passenger kms, millions/year				%	%	%	%
	Business	Private	Work	Sum	Business	Private	Work	Sum
SL	1	20	16	36	15%	54%	34%	41%
SLbus to Arlanda	0	3	3	5	18%	62%	21%	31%
Commuter train	0	9	0	9	15%	51%	2%	36%
Airport coach Stockholm	11	36	1	48	31%	55%	3%	36%
Airport coach Uppsala	0	3	5	8	21%	26%	64%	43%
Intarnal bus Arlanda	0	0	-1	-1		-2%	-19%	-15%
SJ-train	4	37	0	41	19%	23%		22%
TIM-train	2	7	0	10	74%	61%		64%
Arlanda Express	22	22	0	45	41%	56%	0%	47%
Other buses	0	25	5	30	25%	42%	64%	44%
Sum public transport	40	117	9	165	35%	38%	15%	34%
Car parked	-8	-68	-16	-92	-5%	-25%	-15%	-17%
Car lift	0	-53	0	-53	82%	-44%		-44%
Taxi	-34	-17	0	-50	-20%	-74%		-26%
Sum car and taxi	-42	-138	-16	-196	-12%	-33%	-15%	-22%
Sum passenger kms	-2	-21	-7	-31	0%	-3%	-4%	-2%

In total this measure would increase public transport by 34% and reduce car and taxi trips by 22%.

3.3.2 Emissions

The diagram below shows the calculated reduction of carbon dioxide if public transport is improved and subsidised. According to the calculation 22 000 reduction, 61%, of the target 36 000 ton would be achieved with this measure.

Table 3.3.2 Calculated change of carbon dioxide emissions


CO2 change tons - car charge
0
-5000
-10000
-15000
-20000
-25000
Public transport
Car traffic
Sum pass. Trp.

3.3.3 The passengers

The table below shows the calculated changes of generalised cost and consumer surplus for various passenger groups.

Table 3.3.3 Change of passengers' benefits and costs

Measure 2010 compared with Reference 2010	**Air passengers to/from Arlanda**				**Staff**	**Sum**
	Business start in Stockholm	Private start in Stockholm	Business start outside Stockholm	Business start outside Stockholm	working at Arlanda	
No. of trips per year, thousands	6 764	7 085	1 309	2 772	5 921	23 849
ΔGeneralised cost per trip, SEK	-18,67	-22,40	-32,72	-20,12	-5,29	
of which time, SEK	*-18,81*	*-2,38*	*0,96*	*-1,17*	*-0,69*	
of which price, SEK	*0,14*	*-20,02*	*-33,68*	*-18,95*	*-4,60*	
ΔGeneralised cost per trip, %	-3,03	-8,23	-2,05	-2,29	-8,28	
ΔConsumer surplus, MSEK/year	-126	-159	-43	-56	-31	-415
of which time, MSEK/year	*-127*	*-17*	*1*	*-3*	*-4*	*-150*
of which price, MSEK/year	*1*	*-142*	*-44*	*-53*	*-27*	*-265*

With this measure almost all would lose both in terms of money and time.

3.3.4 Welfare

The table below summarises the benefits and costs of the measure.

Table 3.3.4 Summary of welfare changes

Benefits and costs	MSEK/year
Consumer surplus	-415
of which time	*-150*
of which price	*-265*
Private sector finances	211
Cost adjustment	-10
Net public surplus	264
Excess burden	79
External effects	6
Sum	135

Car charges are calculated to generate a substantial social benefit.

3.4 Alternative - Combination

3.4.1 Mode shift

The table below shows the calculated mode shift due to the combination of measures.

Table 3.4.1 Calculated mode shift

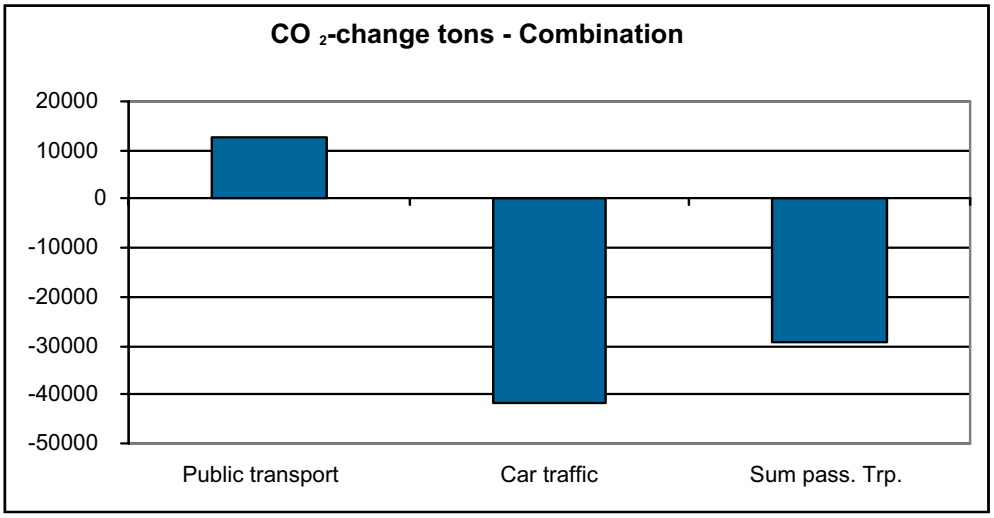
	Change with measure, absolute and in percentage terms							
	Passenger kms, millions/year				%	%	%	%
	Business	Private	Work	Sum	Business	Private	Work	Sum
SL	3	130	48	180	46%	353%	104%	203%
SLbus to Arlanda	0	-2	-2	-4	-26%	-53%	-13%	-23%
Commuter train	2	130	31	162	135%	770%	461%	656%
Airport coach Stockholm	23	61	-2	82	67%	92%	-7%	62%
Airport coach Uppsala	0	17	8	25	58%	171%	96%	137%
Intarnal bus Arlanda	0	-1	-3	-4		-42%	-44%	-43%
SJ-train	1	-19	0	-18	4%	-12%		-10%
TIM-train	11	39	0	50	355%	321%		328%
Arlanda Express	55	-30	1	26	101%	-75%	84%	27%
Other buses	0	37	8	45	13%	63%	96%	66%
Sum public transport	91	195	36	322	80%	63%	60%	67%
Car parked	-17	-83	-40	-140	-10%	-30%	-36%	-25%
Car lift	1	-106	0	-105	258%	-87%		-86%
Taxi	-80	-21	0	-101	-47%	-95%		-52%
Sum car and taxi	-96	-210	-40	-346	-28%	-51%	-36%	-40%
Sum passenger kms	-4	-15	-4	-23	-1%	-2%	-2%	-2%

In total the combination is calculated to increase public transport by 67% and reduce car and taxi trips by 40%. Only this combination seems to affect the mode choice also of the personnel at Arlanda airport

3.4.2 Emissions

The diagram below shows the calculated reduction of carbon dioxide if public transport is improved and subsidised. According to the calculation 29 000 reduction, 80%, of the target 36 000 ton would be achieved with this measure.

Table 3.4.2 Calculated change of carbon dioxide emissions


CO ₂-change tons - Combination
20000
10000
0
-10000
-20000
-30000
-40000
-50000
Public transport
Car traffic
Sum pass. Trp.

3.4.3 The passengers

The table below shows the calculated changes of generalised cost and consumer surplus for various passenger groups.

Table 3.4.3 Change of passengers' benefits and costs

Measure 2010 compared with Reference 2010	**Air passengers to/from Arlanda**				**Staff**	**Sum**
	Business start in Stockholm	Private start in Stockholm	Business start outside Stockholm	Business start outside Stockholm	working at Arlanda	
No. of trips per year, thousands	6 764	7 085	1 309	2 772	5 921	23 849
ΔGeneralised cost per trip, SEK	7,29	20,67	5,13	28,18	-0,29	
of which time, SEK	*-32,36*	*-1,55*	*6,46*	*9,06*	*1,40*	
of which price, SEK	*39,65*	*22,22*	*-1,33*	*19,12*	*-1,69*	
ΔGeneralised cost per trip, %	1,19	7,59	0,32	3,21	-0,46	
ΔConsumer surplus, MSEK/year	49	146	7	78	-2	279
of which time, MSEK/year	*-219*	*-11*	*8*	*25*	*8*	*-188*
of which price, MSEK/year	*268*	*157*	*-2*	*53*	*-10*	*467*

Business travellers and private travellers with starting point in Stockholm and business travellers with starting point outside Stockholm seem to benefit most. Only personnel at Arlanda are net losers.

3.4.4 Welfare

The table below summarises the benefits and costs of the measure.

Table 3.4.4 Summary of welfare changes

Benefits and costs	MSEK/year
Consumer surplus	279
of which time	*-188*
of which price	*467*
Private sector finances	0
Cost adjustment	-119
Net public surplus	-289
Excess burden	-87
External effects	3
Sum	-213

The combination seems to mean a social loss. However, with fine-tuning, for example less subsidies and less increase of the supply of public transport would probably mean a social net benefit.

4 Conclusions

With the passenger transport measures analysed none could fully obtain the carbon dioxide reduction target, but it would be fairly easy to find measures that reach about three-quarter of the target and that are also socially beneficial.

Of course one could increase the car charges and/or improve and subsidise public transport further and achieve the target, but we have not analysed the welfare effect of such stronger measures. One must also keep in mind that high car charges probably will meet substantial resistance, but this is a political matter.

The work also indicates that the VIPS assignment package used seems very competent in analysing a large number of alternative modes and combinations of modes, by taking into account the price and travel time components of each single route, taxi and car.

References

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Appendix Some characteristics of the VIPS system

Importance of the use of timetable

In VIPS it is possible to use the basic assumption that travellers do not use a time table when planning their trips, which is suitable for route network analysis of frequent urban services. However, the system is also capable of utilising the assumption that travellers can use the timetable. The impact of recognising this behaviour will result in radically different results when compared to the assumption that a timetable is not used:

- Travellers are likely to choose between alternative places of departure (bus stops, stations, air ports) and mode specific services when using a timetable, whereas only one alternative is otherwise the case. Travellers then also consider travel time and price of the journey in their choice of mode and route.

Specified transfer times

Normally transfer times are calculated as half the headway, or half the composite headway when there are several routes to choose among. However, where intervals between departures are long this may cause unrealistically long waiting time costs, especially since waiting time typically has a high value of time related to in-vehicle time. The system allows specification of transfer times between all pairs of routes at each stop. Each route pair may thus give rise to 8 different specified transfer times, since the two directions of each route must be taken into account.

Alternative paths

The system generates all possible combinations of modes and routes in order to get from the origin zone to the destination zone. For the Arlanda study the auxiliary modes car and taxi to a public transport stop are in the model represented as direct public transport routes with short intervals and with short specified transfer times to the ordinary public transport routes. Each single route along the entire journey between origin and destination has a specific price and specific travel time components. This means that all alternatives each have a specific price and specific travel time components. Alternatives can be both competing and complementary.

Specific standard of stop or service

Different points of departures and services display varying comfort. Therefore an option exists to adjust the weights for waiting times and riding times accordingly. For example, a comfortable service can be given a lower than average travel time weight.

Fare analyses

VIPS allows for analysis of service specific fares. Either the fare is a function of the distance travelled on each route, or the fare is specified on a station-station basis. Both fare structures

affect the choice of route and the generalised cost. The result of a route network analysis is total revenues, for the different modes and for the individual services. Both the financial results of the operators and the social net benefit are obtained.