# Summary

## The cost-benefit method is robust

Public funds are limited and should be spent where the highest benefits can be achieved. For this reason the Swedish transport investment policy is based on cost-benefit analysis (CBA) complemented with other types of decision support. CBA is a means to systematically compare benefits and costs. Central to all cost-benefit analyses is that two alternative scenarios are designed for the analyzed period: the investment scenario and the no-investment scenario. In the no-investment scenario, it is assumed that the transport system does not include the evaluated investment. In the investment scenario, it is assumed that the transport system includes the evaluated investment.

In this report, we undertake a CBA for the Stockholm Metro applying current Swedish methodology, models and established national guidelines. The CBA is made for the current Stockholm Metro, as if the analysis was undertaken in the 1950s (when the current Metro was built) and as if the methods and models presently used for CBA in Sweden had been available and used at the time.

We use different assumptions in the no-investment scenario. In one analysis we assume that no other public transport infrastructure had been built. In another no-investment scenario we assume that the tram that run along the same corridors as the Metro now does would have persisted. We also vary the construction cost assumption. The CBA is carried out using i) actual construction cost from the 1950s and ii) an estimate of what the cost had been today. We also estimate the long-term effects on the labor market in terms of income growth and on the land-use patterns, which are not included in the standard CBA. The CBA shows a positive outcome for the Metro, and hence that the

Stockholm Metro was a socioeconomic efficient investment. It should be emphasized that since the CBA concerns the current Metro, it gives no indication of the socioeconomic benefits of a possible expansion of the Stockholm Metro at present.

One reason for carrying out a CBA for the Stockholm Metro is to explore the robustness of the CBA methodology. This case study of the Stockholm Metro takes the models and CBA methodology to their limits. This is because the methodology is less developed for large investments in growing urban regions than for other investments. This, in turn, is due mainly to the fact that it is difficult to estimate the benefits of investments that have long-term dynamic effects on the labor market and that have effects on congestion in the road network. Another reason for choosing the Metro is the widespread anecdote that the Metro would not have shown a positive CBA outcome when it was built, which often is said to undermine the trust in CBA.

Even if this project demonstrates that some of the criticism of the CBA methodology is valid for certain types of investments (see next section - the benefits are underestimated), the Metro shows positive estimate outcomes. This lends some legitimacy to the CBA methodology and gives some support to the robustness of the methodology.

## The benefits are underestimated

Although this project shows that the Metro was socioeconomic beneficial to build in the 1950s, some weaknesses of the standard methodology are also demonstrated. Specifically that the benefits of urban investment are typically underestimated for several reasons.

One purpose of this report is - in addition to test the robustness of the CBA methodology - to expose the strengths, weaknesses and development potential of the methodology. We hope that this will provide some guidance concerning the robustness of the CBA methodology and for what types of investments the benefits are likely to be underestimated. This should be helpful in the interpretation of the CBA outcomes.

First, the benefit may be underestimated because long-term dynamic labor market effects are not captured in standard CBA. They are likely to be substantial in cases like the Stockholm Metro,

where the investments are important for commuting, and in particular in highly specialized labor markets. Productivity increases as a result of the Stockholm Metro will increase commuter benefits approximately 60 percent, because the Metro is widely used for commuting and improves matching in the labor market.

Second, the reduction of car travel times in congested road networks, in response to new investments or policies, is underestimated by standard static transport models. The extent to which the benefits of the Metro are underestimated because congestion in the road network is not handled properly in the models is not assessed in the project. However, there is reason to believe that the underestimation is substantial.

Third, congestion and capacity constraints in public transport are usually not handled in traffic models, although capacity constraints and congestion in public transport can and should be considered according to current national CBA guidelines. Hence, benefits of increased capacity in public transport (allowing the maximum number of passengers to increases) and benefits of less congestion on the vehicles and platforms are both often left out of the CBA. In the CBA of the Metro presented in this report, congesting and capacity benefits are extremely important and has been taken into account.

## The increase in capacity is an important benefit

The present analysis demonstrates that the largest benefit of the Stockholm Metro is its high capacity. Travel time savings compared to the bus or tram is rather small. This conclusion provides insight as to where a potential expansion of the current Metro may be more beneficial than investments in other means of public transport: a basic condition is a high population density in the catchment area.

## A Metro can spread out settlements

Much of the current land-use pattern of Stockholm has been planned integrated with building the Metro. We also simulate how the Stockholm land-use pattern could have developed had the

Metro not materialized. The current Metro produces about the same socioeconomic benefits assuming the simulated land-use pattern as it produces in the existing land-use patterns that to a large extent has adapted to the Metro. This is because the simulated land-use pattern is considerably denser than the current, since the benefit of a central high capacity public transport infrastructure is generally large in dense settlement pattern.

The result of the land-use simulation indicates, hence, that Stockholm has developed into a sparser and less dense region than what the market forces would have steered towards. A consequence of the investment in the Metro was that new settlements were planned far from the city center when the Metro was built. However, there is a high demand for living in the dense inner city or the semi-central suburbs, and higher density thus could have been the result had land-use been governed by market forces. Our analysis suggests that the reason for Stockholm not currently being denser is primarily a supply problem; new houses have not been produced in central locations to the extent that it has been a demand for. It should be stressed, however, that land-use development is ruled by a complicated course of events and mechanisms. The land-use simulation thus contains large uncertainties.

The present analysis demonstrates that settlement patterns planned for along tracks far out from the city center increases travel distances and even energy consumption compared to a denser land-use patterns. In the specific relations to and from the inner city the Metro provides effective and energy efficient transport, primarily for commuting. But the sparse settlement pattern also give rise to long distances and higher proportion of car travel especially for other trip purposes in other relations than to/from the city center. Settlements along the Metro corridor far from the center seem thus to have fueled a trend of increasing trip distances and thus weakened the competitiveness of bicycle and public transport particularly in other trip relations than to/from the city.

If comparing the energy consumption (measured as mileage of car traffic) in the two different land use scenarios, the current and the simulated, the analysis shows that energy consumption is 13 percent lower in the simulated land use than in the current land use (assuming that the Metro is built in both scenarios). Meanwhile, energy consumption is 6 percent higher if the Metro is replaced

with a tram in the current land use. Land use can thus have larger impact on energy consumption than the public transport infrastructure.

An important conclusion is therefore that it might have been better not to build the Metro quite as far out from the center. Perhaps a Metro in the city and close suburbs would have been sufficient and even desirable. The demand for housing in central locations is (and probably was) larger than was planned for. This serves as clear illustration of the disadvantage with regional enlargement and extension of the rail systems far out from the center, which is sometimes sought. Good opportunities for long commuting increases matching on the labor market, but, it also increases distances and travel for other purposes than commuting, and imply that other means of travel can become less competitive.