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Rune Wigblad

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55. Maglev trains are enabling regional enlargement with socio-economic effects

Rune Wigblad, Professor Management, Skövde University and Strömstad Academy, Sweden
rune.wigblad@his.se
Mikael Thorsén, Railway Engineer, DSMG[1], Lund, Sweden
Mattias Svederberg, Electrical and Construction Engineer, DSMG, Katrineholm, Sweden

Abstract

Maglev trains with high top speed enable regional enlargement with short travel times. This paper explores two opportunities in Sweden/Denmark. The theoretical concepts are "borrowed size" (Bohman & Nilsson 2021) and "regional enlargement" (Amcoff, 2009), i e benefits from shorter travel times.

A scientific ex-post analysis of the Oresund bridge reveals an increase in daily commuting (Knudsen & Rich 2013). The commuting figures are largely a result of Swedes helping to "plug gaps in the Danish service sector" as well as new professional roles in niche industries.

Based on the lower numbers of commuters in early years, the Knudsen & Rich (2013) evaluation was adjusted and this gave the Oresund bridge a payback time of 17 years. 73% of the commuting benefits derive from labor market effects, i e mostly increased commuting. Such an Oresund bridge effect appears when commuting time is less than 45 minutes due to a "threshold" effect, (Cassel et al., 2013) which is present in our cases.

Conclusion: With maglev train from Gothenburg to Copenhagen/Malmö the socio-economic payback time is estimated to be shorter than for the Oresund bridge.

Policy recommendation is to start investigations in maglev Feasibility studies in Sweden

[1] DSMG = Den Skandinaviska MagnettågsGruppen. https://www.dsmg.se/

Introduction

Improvements and expansions of existing transport infrastructure may have substantial effects on labor markets in a region, usually by reducing commuting times. This paper addresses large-scale investments that enable entirely new commuting behaviors, due to radically reduced travel times. Such changes are difficult to estimate since most models are adapted to deal with smaller, incremental improvements in existing connections, and are not suited for addressing large-scale disruptive changes, such as the introduction of a whole new mode of transport, or construction of completely new high-speed lines.

Close geographical proximity between organizations has by some researchers been suggested to increase economic activity such as industrial districts (Harrison, 1992), clusters (Porter, 1990), learning regions (Morgan, 1997), regional innovation systems (Cooke et al. 1997) and creative cities (Florida, 2002). Households need access to jobs, public services and leisure activities. Businesses need access to labor, suppliers and customers. The benefits of being close to other actors, often referred to as agglomeration economies, have been extensively studied in the field of urban and regional economics (Melo, Graham, & Noland, 2009).

All above mentioned agglomeration concepts are relevant, albeit static entities. This paper addresses dynamic cases, i.e. investments that affect the preferred mode of transportation and create new agglomerations. The relevant dynamic concepts are here “regional enlargement” (Amcoff, 2009) and “borrowed size” (Bohman et al 2021) which address the effects of major changes.

Alonso (1973) introduced the concept “borrowed size” with the meaning that a town or city benefits from being close to large markets. The integration of two metropolitan cities through reduced travel times can thus be viewed as an increase in opportunities for mutual borrowed size. This implies that investments enabling substantial travel time reduction between two metropolitan cities creates borrowed size effects, thus bringing social networks closer together. The Öresund bridge (Oresund in English and Øresund in Danish) provided such integration of two urban networks that offered households and corporations the ability to reach more opportunities of mobility.

Large-scale investments in infrastructure which create new transport solutions do not always come with big benefits or substantial travel time reduction. The first Swedish pilot project for high-speed rail is scheduled for construction start in 2024 (mostly preparational ground works). It will be a rail corridor between Linköping and Järna (160 km) with several stations and a top speed of 250 km/h. This velocity may however be difficult to reach if the train stops in both Norrköping and Nyköping, due to the low acceleration capacity in high-speed rail systems. Since the maximum speed of the existing rail infrastructure is 200 km/h, the travel time benefits in relation to the high investment cost (ex-ante appr. 10 billion euro) is expected to be relatively low. An important factor regarding the low travel time reduction-to-investment cost-ratio is in this case the fact that the new line is replacing an already existing one between the communities involved, in contrast to cities without existing and efficient connections.

This was not the case with another large-scale investment, the Oresund bridge between Malmö and Copenhagen. The bridge, which opened in July 2000, was a new cross-border connection between Sweden and Denmark, as well as the longest combined road and rail bridge in Europe connecting two major metropolitan areas. Before its commission, the travel time between Malmö and Copenhagen was more than 90 minutes via the HH-link (Helsingborg – Elsinore). The direct ferry had limited numbers of departures, did not run during nights, and took approximately one hour. Through the new bridge, average travel times between the respective city center was reduced to 27-30 minutes by train and 35 minutes by car, replacing the former ferry connection. Thus, the new connection cut travel times in less than half and substantially increased availability.

It is possible to learn from cases like the Oresund bridge since several evaluations have been made ex-post, which reveal several benefits due to dramatically reduced travel times. This paper first reviews the factual evaluation of the Oresund bridge and then discuss possible comparability with the enabling of shorter travel times with maglev train on two selected tracks.

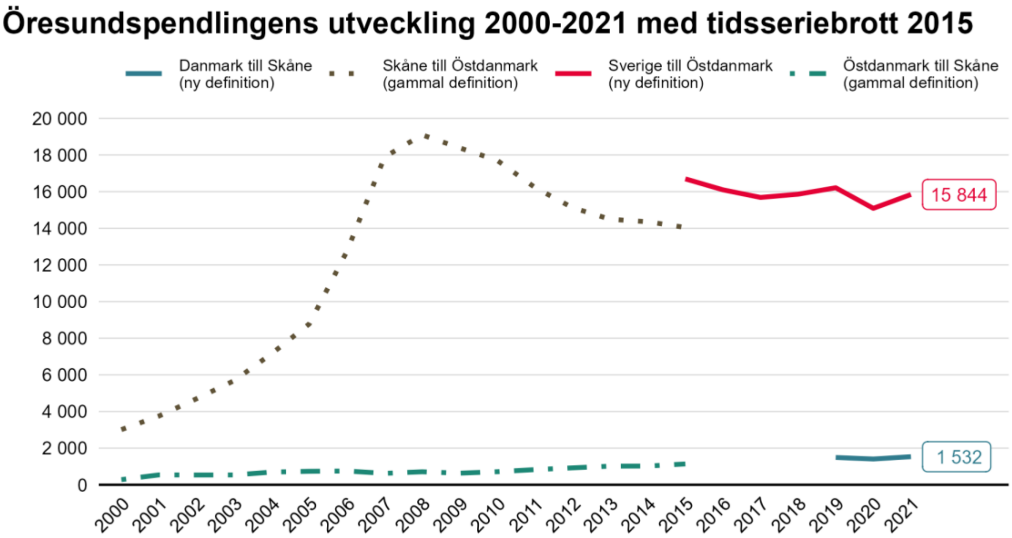
Review of the state-of-the-art knowledge about the Oresund bridge effect

Research addressing the Oresund bridge effects are today well founded. Several researchers have identified two main effects:

1. Increase in commuting behavior.
2. Enlarged and borrowed labor market.

Policymakers have notably been very positive to the experienced effects of the Oresund bridge and are currently discussing possibilities for an additional connection across the Oresund strait. Commonly, policymakers also take non-quantifiable benefits into consideration when evaluating large investments of this kind. A nonscientific report published in Denmark 2019 estimated that the bridge has generated more than €8 billion SEK in increased wealth in 12 years, compared with the appr. €5 billion used to build it (cited in Oresund bridge: the birth of a new region- We Build Value). Such estimations are however difficult to substantiate.

A scientific ex-post analysis of the Oresund bridge focuses on variables possible to quantify in a Cost/benefit analysis (Knudsen, et al 2013). There has been an increase in daily commuters up to the level of 16 000 per day (except for the pandemic period). 6-7 years after the opening of the bridge, this high level of commuters reached high steady level according to *Figure 1*.



Figur 18: Öresundspendlingens utveckling från 1997 till 2020. Observera tidsseriebrott 2015. Data för pendling 2000 till 2015 omfattar endast pendling mellan Skåne och Östdanmark. | **Källa:** Öresundstatabasen Örestat.

Figure 1. Number of daily commuters on the Oresund bridge over time. A new definition for data was established in 2016 (Örestat 2024. Öresund sedan år 2000 (skane.se)).

The cost/benefit analysis by Knudsen et al (2013) was carried out ten years after the opening of the bridge in July 2000 and reveals that the bridge ten years later had generated significant consumer benefits, "which over a ten year period discounted at 3.5% p.a. to 2000 amounts to 2 billion € in 2000 prices, which amounts to 53% of the construction cost".

Since this result is based on the first ten years data it was underestimating the commuters and also benefit pay-back for the Oresund bridge effect by appr. 35% compared to what an evaluation for the 10 following years would give according to figure 1. A recalculation gives us a pay-back of at least 70% for the following ten-year period 2010-2020. Based on findings in this article, the socio-economic pay-back time for the Oresund bridge project was thus less than 17 years.

Furthermore, the Knudsen et al (2013) empirical results show that about 73 % of the benefits was related to the labor market.

The Oresund enlarged and borrowed labor market

According to an economic geography research report, the impressive commuting figures are in the Oresund case largely a result of Swedes helping to "plug gaps in the Danish service sector" as well as new professional roles in niche industries.

Bütikofer et al (2020) give more detailed empirical evidence on what the labor market gains are in the Oresund case. Most important was the wage increase by 15% for the commuters, mainly from Malmö to the larger labor market in Copenhagen. It was the possibilities connected to the larger market in Copenhagen that created this "borrowed size" effect. The gradual increase of commuting on the bridge was a gradual effect, with a larger effect occurring between 2005-2008, mainly due to labor shortage in Copenhagen and high unemployment rates in Malmö. This new institutional structure was permanent thereafter.

Another notable integration gain was that Danish residents had the opportunity to by houses in the greater Malmö region without leaving existing jobs in Copenhagen.

Discussion of comparability between cases

This paper took its starting point by reviewing the well documented effects of the Oresund bridge ex-post and now continues with a comparative discussion with two other possible cases enabled by fast land transport using maglev technology. The cases are ex-ante and selected since maglev (EMS) with a top speed around 500 km/h could, similarly to the Oresund bridge, substantially reduce travel times for commuting and thus theoretically yield some comparable effects. The cases with regional enlargement and borrowed size are;

1. Oresund bridge between Malmö and Copenhagen
2. Maglev (EMS) between Gothenburg and Copenhagen (double track)
3. Maglev (EMS) between Uppsala and Vasteras connecting Stockholm (double track)

The common starting point for comparing the cases is the general reduction in travel times by the magnitude of 50% or more, resulting in travel times within the so-called threshold for daily commuting.

The definition of long-distance daily commuting varies from country to country, mostly based on commuting distance or time. In terms of commuting distance, studies in Europe and the United States took 30- 100 km (Andersson et al., 2018; Sandow and Westin, 2010) and 80-160 km (Lapham, 1995; Sivaraman, 2015) as the threshold of long-distance commuting, respectively. Regarding commuting time, 30–45 min is generally considered to be the threshold of commuting time that travelers can bear (Clark et al., 2003). Some other previous studies used 40–45 min as the threshold for long-distance commuting (Clark et al., 2003; Sandow and Westin, 2010). For instance, Cassel et al. (2013) defined long-distance commuting as "a journey to work taking at least 40 min".

Since individuals are more sensitive to commuting time than commuting distance (Öhman and Lindgren, 2003), we chose >45 min as an indicator of long-distance commuting, which is the turning point for changes in behavioral preferences (Huang et al., 2018; Stenpaß and Kley, 2020, LI, Y. et al. 2022). This is specifically true if the train travel can be combined with work during travel time, which is possible in case 1 and 2, but not with traveling by car over the bridge. This reduces the short commuting time advantage for case 0 over case 1 and 2. But, on the other hand traveling by car has the advantage of flexibility since it is possible to reach destinations without changing transportation mode.

Travel times in cases

The case specific travel times are:

1. Average 35 minutes
2. 40 minutes direct train Gothenburg – Copenhagen and shorter for intermediate stations
3. 20 minutes from Uppsala and 30 min from Vasteras direct train to Stockholm and shorter for intermediate stations

All cases are within the commuting threshold, >45 min, as our indicator of long-distance commuting. The shorter travel times in case 2 gives this case an advantage over case 0 and 1.

Context specific distances and tracks

The studied cases compare one bridge project (0) with two maglev train projects (1 and 2). Travel distances in our cases are:

1. 41 km (Malmö – Copenhagen)
2. 274 km (Gothenburg – Copenhagen)
3. 70 km (Uppsala – Stockholm); 105 km (Västerås – Stockholm) = 175 km

The train line between Malmö and Copenhagen is relatively short, 41 km compared with the distances for the studied maglev lines. It might be possible for a maglev train from Gothenburg to Copenhagen to use the existing Oresund bridge when the track reaches Malmö, i.e. borrowed investment infrastructure. The feasibility of this is however not investigated and a separate connection may be required. The Gothenburg – Copenhagen maglev track (case 1) also offer a possible **synergy effect** connecting Malmö to Copenhagen with a much faster connection than today, enabling very short travel times by maglev train down to 10 minutes. Another synergy effect in case 1 is the possibility to have a maglev train station stop in Helsingborg with approx. 105 000 inhabitants integrated into the Malmo/Copenhagen region with travel times 20-30 minutes.

Freight transportation

Persson et al (2022) noted that the Oresund bridge had significant trade effects. This is mainly the bridge effect with regard to freight transport. This gives the Oresund bridge effect a significant advantage compared to case 1 and 2, since freight transport in the maglev cases are only relevant for lighter goods up to 40 tons.

One relevant effect of minor importance for all cases is the improved possibility for face-to face communication which is important as a complement to digital communication channels.

Inhabitants

The first maglev case involves Copenhagen and Gothenburg. Gothenburg is appr. twice the size of Malmö if the greater metropolitan area is included, which together with the city center end up to 760 000 compared to 362 000 in Malmö. Malmö can also be seen as a little bit larger when close to city center suburbs are included.

The second maglev case involves Uppsala and Vasteras with together 445´ inhabitants and Stockholm have appr. the same size as Copenhagen.

Airport connections

All cases involve airport connections. Copenhagen has the large airport Kastrup and the integration of Malmö gave this airport an advantage compared to the small airport Skurup with 1.3 million passengers (2023) 30 km outside Malmö. One out of five Kastrup passengers comes from Sweden. The large airport Kastrup with appr. 27 million passengers (2023) would benefit further if there were a fast connection between Gothenburg and Copenhagen. 30 km outside Gothenburg is the Landvetter airport with 5.2 million passengers (2023). This airport would face stronger competition from Kastrup within case 1.

Case 2 on the other hand involves the integration of Arlanda Airport with 22 million passengers (2023). The travel time from nearby metropolitan areas (Stockholm city, Uppsala, Västerås) to Arlanda would be less than half time compared with the situation today, which would increase the competitiveness for Arlanda airport. A synergy effect would be the possibility to connect Arlanda and Västerås airport with a fast scuttle connection, less than 20 minutes, as an alternative to build a new runway at Arlanda

Investment cost comparison

Investment cost estimations are all in Billion (B) € (Euro). The estimation of case 0 (Bridge) is based on factual costs that have been indexed to present date. The estimation of case 1 and 2 (maglev) is based on a key ratio according to Appendix. Case 1 and 2 **ratio** derives from a thorough investigation by the authors of one part of case 2, the Västerås-Arlanda track, april 2024 (see **Appendix**). 35 billion SEK for 80 km translates to **440 million SEK per km or 38 million Euro per km**.

- The Oresund Bridge: 38 billion SEK for the bridge in 1999 gives approx. 5.2 B € in 2024 with price index adjustment.
- Maglev Gothenburg – Copenhagen: Estimation: **12 B € (2024)**, excluding a new tunnel under the Oresund strait.
- Maglev Uppsala – Stockholm: Estimation: **6.6 B € (2024)**

In addition to the investment for the Oresund bridge, comes the train and road investments in case 0. Case 0 provides an accurate figure for the bridge construction only and for comparison, costs for rail and road construction, 41 km, must be added. A more accurate comparative estimation is therefore in the magnitude of **6 B €.**

Case 1 is excluding the cost for a new tunnel under the Oresund strait. If such a tunnel should be required, it would most likely be coordinated with one of the proposed new fixed links between southern Sweden and Denmark. Such a new link is expected to be necessary after 2050 (Trafikverket 2024) with regard to the available capacity on the Oresund bridge, but may be commissioned somewhat earlier due to regional policy demands (however most likely not before 2035). One factor in favor of earlier additional capacity is the lack of alternatives for rail connection, i.e. the existence of a redundancy problem. The proposals for such a Oresund link are described below:

1. An Oresund metro: extension of the metro system in Copenhagen into Malmö. This project gives mostly regional benefits but may reduce the train congestion at the landside connections of the Oresund bridge (train capacity on the bridge itself is by the Trafikverket report (2024) expected to be sufficient until 2050).
2. A tunnel between Helsingborg and Elsinore: This link would be of significant regional importance as well as important for long distance trains. A road connection is proposed as well. Unresolved questions exist about the infrastructure on the Danish side, besides issues considering land acquisition may however be significant hindrances for the project. The steep inclines are expected to hamper freight traffic. Such hindrances may however be possible to overcome by using multiple locomotives and/or auxiliary trackside linear motors.
3. A tunnel between Landskrona and Copenhagen: This link is more important for long distance trains and has somewhat less regional importance. However, such a link would require considerable landside- and tunnel investments due to the need for relocating the current rail yard in Malmö because of new traffic patterns.

According to a recent report from the Swedish Transport administration (Trafikverket, 2024), none of the above proposed connections fills all the identified transport demands, neither from a regional nor from a national perspective. The report is however not taking into consideration the socio-economic effects such as increase in passenger traffic (e.g. increased commuting) if travel times are reduced by half, which will typically appear with maglev solutions. The report is also narrowing down to the Oresund strait area with the comparably smaller metropolitan areas involved (Helsingborg, Landskrona and Elsinore), not taking Gothenburg into consideration. A wider perspective including Gothenburg could also include solutions for these comparative smaller metropolitan areas. We therefore conclude that further studies are needed and - given the time horizon - stress the importance of including maglev technology in these studies.

A critical question raised is if the effects of investment in our maglev cases are sustainable?

Sustainability

For a region to be considered sustainable, at least in economic terms, the requirement of positive population growth is usually assumed. There exists a mechanism between infrastructure and population growth.

This paper follows the sustainability effects identified by Ny (2022) addressing the economic and socio-ecological sustainability principles:

- Effects on the Traffic system
- Effects for Humans

- Effects for the Environment
- Effects for the Societal Economy and Resources

Ny (2022) compared upgrading existing systems; four high-speed rail alternatives with two maglev systems (EDS and EMS). The EMS-maglev was found most sustainable in this assessment of the above-mentioned sustainability principles, which is also the focus of our comparison in this paper.

With the Ny (2022) evaluation as a base-line, there are mainly two factors that provide strong socio-economic benefits and enhance growth:

1. The Socio-economic effects of the Oresund bridge point to short pay off times.
2. The Cost-benefit effects of the Oresund bridge point to increased commuting using the opportunity to higher wages.

Infrastructure investments may, due to improved accessibility, enlarge labor market regions. Such larger regions provide a better foundation for attractive industries, resulting in more jobs, influx of labor and population growth. Alternatively, enhanced infrastructure increases accessibility. This helps industries to remain in a region even despite pressure to relocate to more central regions, due to large distances and transport uncertainties. (Aarhaug, J. et al. 2017)

Trains with top speeds at 500 km/h enable regional enlargement at a significantly larger scale than most other infrastructure projects, including that of high-speed rail, by connecting remotely separated cities through more than half travel times.

Comparative analysis

To estimate the effects on travel demand, economic feasibility, and societal welfare from maglev investments, we make a comparison with the ex-post evaluation of the Oresund bridge:

Variable \ Case	0. Malmo/ Copenhagen bridge	1. Gothenburg/ Copenhagen **&** Malmo. Maglev train	2. Uppsala **&** Vasteras /Arlanda/Stockholm. Maglev train
Inv. cost (Billion €)	3,4 B + (1999) = **6 B** (2024)	Estimation **12** B (2024)	Estimation **6,6** B (2024)
Inhabitants	362’ vs 1200’	700’ vs 1562’	445’ vs 1300’
Commuting travel time	35-45 min	40 min direct train + shorter for intermediate stations	20 & 30 min direct train + shorter for intermediate stations
Transfer of passengers	From boat to cars, busses and trains	From flight and cars/busses to maglev. Free up capacity for freight	From cars and busses to maglev. Free up capacity for freight
C/B pay back time - quantifiable data	**17 years**	Estimation **14 years**	Estimation 17-**18 years**

Table 1 Comparative analysis - key ratios based on quantifiable data in the Oresund case and estimations in Case 1 and 2.

From a socio-economic perspective all cases have positive Cost/Benefits with comparably short socio-economic pay-back times. Infrastructural investments usually have longer pay-back times.

Case 2 has the comparative advantage of the shortest commuting times, but does not have a cross country connection which is a comparative disadvantage.

Case 1: Gothenburg has twice the population compared to Malmö, but also involves twice as high investment cost. A possible synergy-effect is the involvement of Helsingborg with a population of 150´ inhabitants, that can be connected with a station along the track. If a future crossing of the Oresund for the maglev train is done in H-H (Helsingborg – Elsinore) an additional link between Helsingborg and Malmö (appr. 60 km) is a possible complement. This can be seen as an important regional connection with half travel time.

This paper only made rough Cost/Benefit estimations serving as indicators that are of interest in order to make the first feasibility studies concerning all relevant variables in case 1 and 2.

Flyvbjerg (2007) investigated 258 large investments in infrastructure and found that a large cost increase, appr. 45%, ex-post compared to ex-ante, for railway projects. The report also concludes that estimations have not improved over time. The risk for cost excesses compared to the results from a feasibility study of a new technology such as maglev, are however less likely as in conventional rail technology cost assessments. The main reason for this is that the industrial mass production process of EMS maglev systems, i.e. a guideway consisting of prefabricated segments built on pillars, which are transported (comparably light weight) to the construction site. This increases the possibility for strict cost control. The EMS maglev also reduces the need for expensive and hard-to-predict costs for tunnels compared with high-speed rail, due to higher flexibility (smaller curve radii and higher climbing ability). Such performance is economically advantageous in the Swedish context with a varied, and often hilly, landscape.

Discussion

The most important effect of the Oresund bridge is related to workers commuting from Malmö to jobs on the enlarged labor market in Copenhagen, and thus creating an increase in growth. This mainly led to large average wage gains among Malmö residents on jobs in Copenhagen. Hence it is relevant to discuss the future of daily work commuting. Large infrastructure projects are long term investments and in our case 1 and 2, more than 15 years ahead, and after construction lasting for at least 60 years. With such time frames a lot can happen concerning restructuring of the labor market conditions.

As a consequence of the Covid pandemic and advancements in digitalization, the shift from traditional office work to remote work has led to today's new hybrid work environments. Hybrid working arrangements balance the benefits of being in the office with the benefits of working from home. How much distance work could we expect in the long-term future?

Several scholars have tried to research this question by assessing the situation today and predictions for the near future. They find that there is an increase in flexible working models enhancing the amount of hybrid workplaces as a new standard. Employers are in favor of this flexible model for knowledge workers since it provides high performance. For the employees it involves better work-life balance. Modern information technology enables good communication connected to distance working during periods of time (Espresson et al., 2023). Research on Teleworking reports that younger employees and those with higher formal education and income are more likely to be high degree of home-based teleworkers. The high frequency home-based teleworkers (>50%) also have longer commuting distances (Asmussen et al 2024). So, in the near future it will likely be more common to have home-based work situations and combine them with comparably long commuting times.

In the long distant future some factors still remain in favor of physical work places. In order to maintain daily dialogues, emotional and informal contacts, creative meetings, social support, project work and good team contacts there is a need for physical work places. Presently and in near future companies often suggest employees to work two days a week at home, focusing on individual tasks or small meetings, and three days a week in the office, for larger meetings, training and social events (Bloom 2021). This balance between working hours and distant work could be altered in the future, but there seems to be a strong need for commuting on part time basis even in the distant future.

It is plausible to assume that some kind of regular commuting is interesting for employers also in the future given the very costly experiences of "Fly in - fly out"-arrangements for qualified workers. The employer then organizes and pays for transportation to and from the worksite, and for worker accommodations and other services at or near the worksite.

Karacan (2023) also points out that by being mobile across the borders, commuters aim at gaining flexibility and a relatively advantageous position in housing and labor markets of different countries. This flexibility is an interesting equalizing mechanism when the development of country specific labor markets differ during periods of time, due to changes in the economy. Such adjustments are likely to be interesting also in the distant future.

Given the discussion above there are several borrowed size effects that seem to be sustainable over time.

Conclusions

The EMS maglev is a satisfactory sustainable solution (Ny 2022), but it also has some features that provide strong comparative advantages. EMS maglev systems enable rapid personal transport solutions with less than half travel times compared to today and give reliable journeys (better than 99% punctuality for the Shanghai maglev), with the possibility to achieve reasonably low ticket prices for passengers mainly because of rapid pay-back time on investments and low operating costs for the society. Similar to the factual Oresund bridge the maglev systems in the counterfactual cases 1 and 2 enable disruptive changes with very short travel times, within the threshold of commuting.

The holistic patterns of our comparative analysis reveal clear similarities in two counterfactual cases compared to the experience (ex-post) from the factual Oresund bridge effect. Important comparative socio-economic ratios valued together indicate that the maglev train cases enable positive Cost/Benefit effects similar to the Oresund bridge. This includes regional enlargement with borrowed size increasing daily commuting with higher wages and increased possibility for favorable housing conditions.

Case 1 provide a very close comparison with the Oresund bridge since both cases involve the same cross-country connection and because Gothenburg is enlarged with borrowed space to both Copenhagen and Malmö, two metropolitan areas.

Case 0 gave the Kastrup airport a small comparative advantage, integrating the Malmö region and Copenhagen with shorter travel times. This comparative advantage will probably be more prominent if Gothenburg would be integrated and borrowed space with Copenhagen in case 1. Case 2 on the other hand would integrate the north Stockholm region with Arlanda airport.

From a Nordic perspective the benefits from both case 1 and case 2 together would balance the Denmark and Sweden comparative advantages.

Our **policy recommendations** are to start investigations with factual based Feasibility studies concerning case 1 and 2, with the aim to explore new growth opportunities. This has not been done to date.

This paper has focused on the benefits in Cost-Benefit analysis and socio-economic evaluations and comparisons. Another question that need further investigation is if case 1 and case 2 are suitable business cases over the lifecycle of the tracks. We know that Maglev trains have comparably low operational costs (i e low labor intensity, maintenance and energy consumption) but that has to be calculated with details concerning all the actual tracks in case 1 and 2. A business case study are usually including pricing policy for tickets and our estimation is that it is possible to offer fare tariffs. One argument that this paper substantiate, in favor of that, is that the price elasticity for commuting passengers are good since they are mainly highly qualified workers that increase their salaries due to rapid transit.

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References connected to Appendix

Costs Transrapid

Rainer Schach, Peter Jehle, René Naumann. (2006), "Transrapid und Rad-Schiene-Hoch-geschwindigkeitsbahn"

"Tabelle 6.12 Gegenüberstellung der Investitionskosten der Transrapidstrecke in München" 272

"Tabelle 6.8 Zusammensetzung der Investitionskosten bei den Eisenbahnneubaustrecken Hannover-Würzburg und Mannheim-Stuttgart" 269

Bridge costs

https://www.researchgate.net/figure/Technical-and-cost-data-of-various-bridges-constructed-in-Europe_tbl2_260290719

Table 3 - uploaded by Dimitrios Konstantinidis

Erik Hansson, Andrë Rosengren (2013), "Järnväg på bro"

3.5 Investeringskostnad

Tunnel costs

https://civils.ai/cost

Calculated as of to specification

Noise prevention costs
John A. Volpe National Transport System center (2002), "Noise Characteristics of the Transrapid TR08 Maglev System)
"B.2 Reference Concrete Guideway " Full Appendix B.

Railway depot costs
https://www.jlt.se/nyhetsarkiv/den-nya-tagdepan-ar-invigen/
"Fakta om nya tågdepån"

Construction company cost
https://trafikverket.diva-portal.org/smash/get/diva2:1738894/FULLTEXT01.pdf (2022)
"Finansiell Redovisning" (135)

Appendix

The information below is given in Swedish SEK (11,6 SEK is appr. 1 Euro).

The sources of the cost estimations are listed in the end of the References - **References connected to Appendix.**

First Kenji Eiler (Maglev Board) made a lining of the track:

Key values

Bridge	2,1 km	2,6 %
Elevated	50,4 km	61,8 %
Ground level	19,5 km	23,9 %
Cut trench	7,1 km	8,7 %
Tunnel	2,4 km	2,9 %
Total	**81,5 km**	

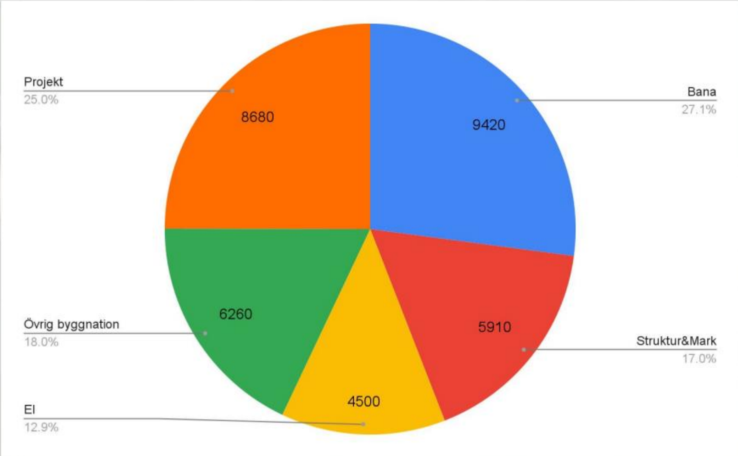
Type 1 – 24,8 m span	4242 pcs.
Type 2 – 12,4 m span	4296 pcs.
Type 3 – 9,3 m span	513 pcs.
2-way switches	9
3-way switches	7
Vmax.	450km/h
a_{max_z}	1,1 m/s²

Soil to be digged out (trench):	335.151 m³
Soil needed to be filled (bank):	64.297 m³ / 19,2 %
Tunnel cross section per single track:	86 m²
Tunnel volume to be digged out:	409-360 m³

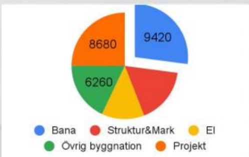
Per single track-km:	
Concrete:	2896 m³/km
Steel:	57,1 m³/km
Aluminum:	5,9 m³/km
Rubber:	20,4 m³/km

Second, the costs were estimated as follows:

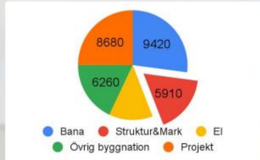
Kostnad



Bana

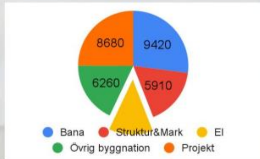


Bana	Msek
25 meters segment	5020
Pelare (Medelvärde)	660
Stora fundament	1630
9.3 meter	1480
Små fundament	710



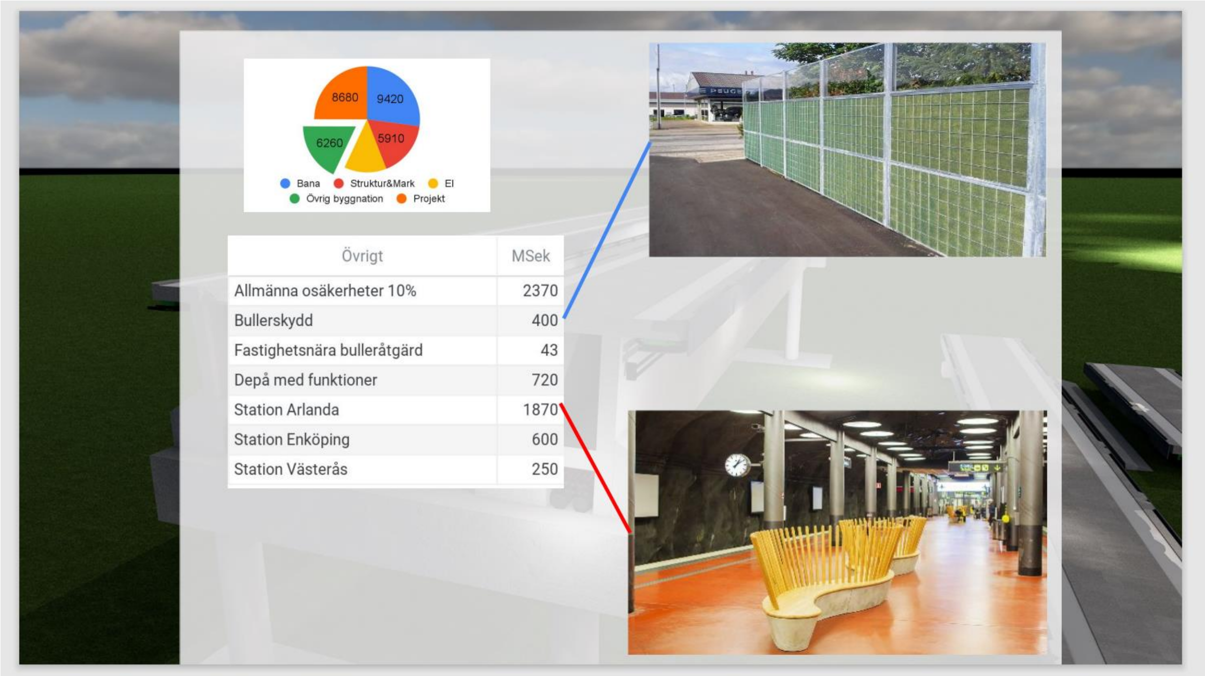
Struktur Mark

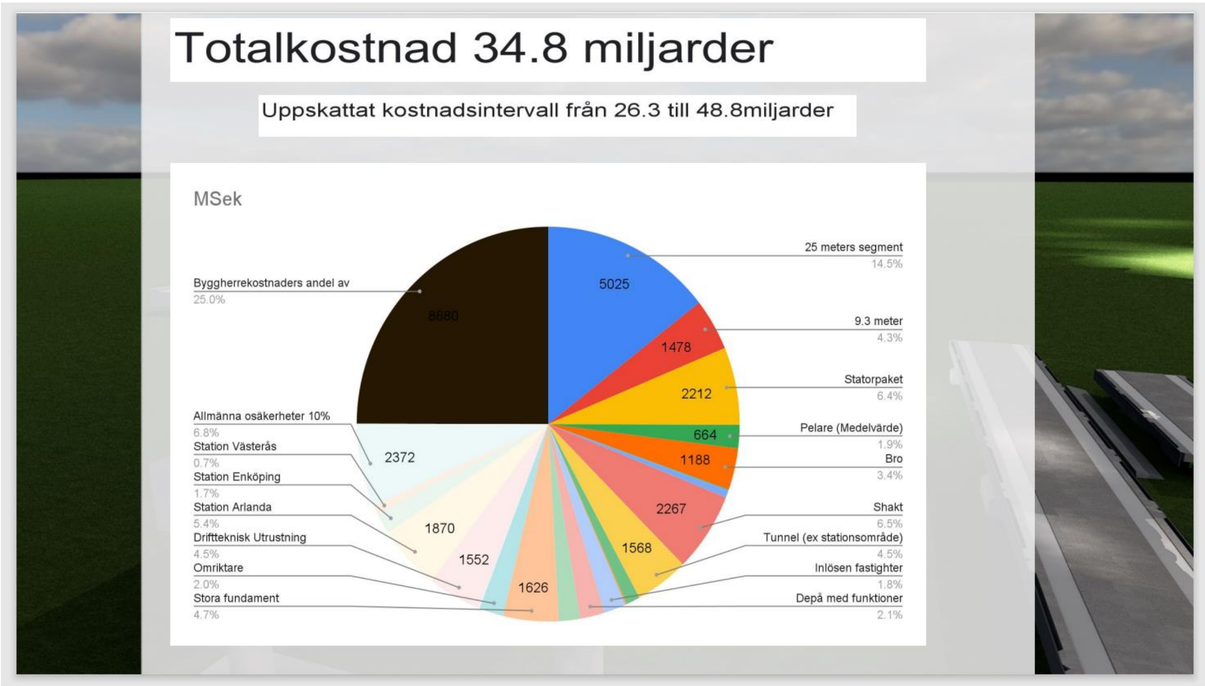
Struktur&Mark	MSek
Bro	1190
Tunnel (ex stationsområde)	1570
Serviceväg	34
Byggväg	200
Shakt	2270
Inlösen fastighter	640
Marklösen korridor	14

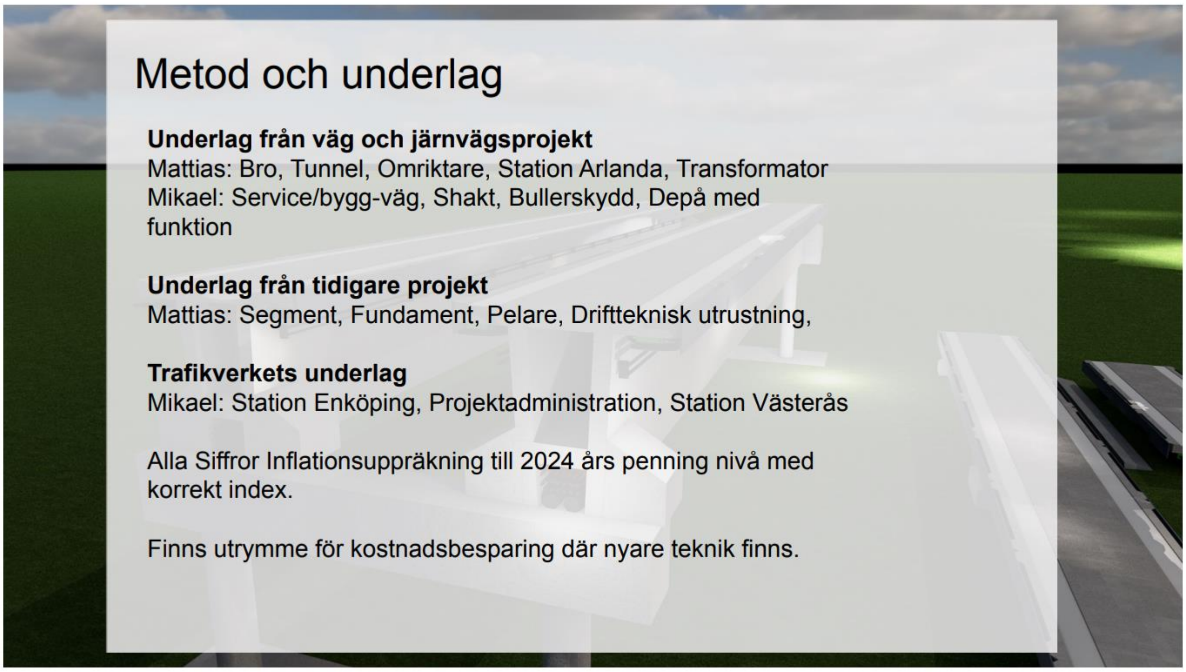


El

El	MSek
Statorpaket	2210
Omriktare	710
Transformatorer	32
Driftteknisk Utrustning	1550


8680
9420
6260
5910
Bana
Struktur&Mark
El
Övrig byggnation
Projekt
Övrigt MSek
Allmänna osäkerheter 10% 2370
Bullerskydd 400
Fastighetsnära bulleråtgärd 43
Depå med funktioner 720
Station Arlanda 1870
Station Enköping 600
Station Västerås 250


Totalkostnad 34.8 miljarder
Uppskattat kostnadsintervall från 26.3 till 48.8miljarder
MSek
Byggherrekostnaders andel av
25.0%
8680
5025
25 meters segment
14.5%
1478
9.3 meter
4.3%
2212
Statorpaket
6.4%
664
Pelare (Medelvärde)
1.9%
1188
Bro
3.4%
2267
Shakt
6.5%
1568
Tunnel (ex stationsområde)
4.5%
Inlösen fastighter
1.8%
Depå med funktioner
2.1%
Allmänna osäkerheter 10%
6.8%
2372
Station Västerås
0.7%
Station Enköping
1.7%
Station Arlanda
5.4%
1870
Driftteknisk Utrustning
4.5%
1552
Omriktare
2.0%
Stora fundament
4.7%
1626


Metod och underlag
Underlag från väg och järnvägsprojekt
Mattias: Bro, Tunnel, Omriktare, Station Arlanda, Transformator
Mikael: Service/bygg-väg, Shakt, Bullerskydd, Depå med funktion
Underlag från tidigare projekt
Mattias: Segment, Fundament, Pelare, Driftteknisk utrustning,
Trafikverkets underlag
Mikael: Station Enköping, Projektadministration, Station Västerås
Alla Siffror Inflationsuppräkning till 2024 års penning nivå med korrekt index.
Finns utrymme för kostnadsbesparing där nyare teknik finns.