Travel Demand Review

A study performed within the government assignment regarding New Main Lines for high-speed trains 2020/2021

March 2021

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Background

In June 2020, the Swedish Government asked Trafikverket to provide updated and supplementary information regarding new trunk lines for High-Speed trains for the Stockholm – Gothenburg and Stockholm – Malmö sections within a total investment framework of SEK 205 billion in 2017 prices. As part of this, an analysis of the effects on long- and short-distance passenger travel demand and effects on air traffic was required.

Work has been undertaken within Trafikverket to answer the questions based on the models and tools that the authority has at its disposal. This means that estimates for long-distance and short-distance travel as well as transfer effects on flights and car traffic were being produced. Jacobs has been asked to undertake a review of the results produced by Trafikverket and to provide a second opinion on the forecast based on international experience.

The demand forecasts provided by Trafikverket are based on the Swedish national transport model Sampers. The Sampers demand model predicts future demand levels by mode of transport, which are assigned to highway and public transport networks using EMME software. Key inputs to Sampers are changes in real income, fuel prices, employment and population. Future network changes are coded in the EMME assignment model.

Present day demand

From the available information we have reviewed present day demand levels (2019) against those reported for the 2017 base for the Sampers forecasting model. There are some significant differences between the two sources.

Present day demand (2019) for Stockholm-Gothenburg/Borås is around 5.7m passengers which may be compared with 6.6m in Sampers for 2017. On mode share, both suggest a consistent share of 18% to 20% for air. Car shares are higher (and rail shares correspondingly lower) in the Sampers numbers compared to the 2019 observed data.

The totals for the Stockholm-Malmö/Lund corridor are more closely matched between the 2019 data and the 2017 Sampers Base at around 3.6 to 3.8m. On mode share, the 2017 Sampers base matches the 2019 data more relatively closely.

It is evident from the base year data that demand to Copenhagen by all modes is not fully represented in the Sampers model.

Data made available by Trafikverket suggests that the combined travel market from Sweden and Denmark to European destinations in the UK, the Netherlands, Belgium, France and northern Germany which could potentially be in scope for longer distance High-Speed rail services amounts to around 8.5 million trips today. We understand that the current demand modelling does not capture the potential to attract some of this demand to High-Speed rail.

Past demand trends

We have reviewed information on past demand trends since 1950 against the underlying demand drivers, together with some limited data on past forecasting performance.

Real GDP per annum since 1950 has been around 2.66%. This may be compared to the approximate growth in total travel demand since 1950 which gives annual growth of some 2.76% per annum on average. From this we can calculate an approximate travel demand/GDP elasticity of +1.04.

If we look at the approximate growth in long distance Public Transport travel demand since 1950, we calculate annual average growth of approximately 1.84%, which gives a long-distance public transport demand/GDP elasticity of +0.7. While no data is available on the growth trend for long distance car demand, it is likely that this has also grown at significantly higher rates than the other modes. Thus, if car demand were included, it is likely that the elasticity of long-distance total demand to GDP would increase closer towards +1.0 in line with findings elsewhere.

More recent trends show that since 2001 rail demand has increased substantially and at a much higher rate than expected. This has been mainly at the expense of domestic air and car demand.

Future forecast without High-Speed rail

With the modelling inputs we have been able to examine, the forecast growth in demand for the Stockholm-Gothenburg and Stockholm-Malmö corridors appears realistic. While these inputs include some very aggressive population growth projections, in particular for Stockholm and Skåne counties, we also note that overall growth in travel demand still falls short of projected GDP growth.

Considering the growth by mode, the low growth in demand for air travel is in line with recent trends. Car demand is predicted to grow more strongly than rail demand in both corridors but more significantly so on the Stockholm-Malmö route. We note that this is not in line with recent trends where demand for rail travel grew much more strongly than demand for car travel. However, this may in part have been driven by the rail investment made since the start of the century and similar levels of investment are not envisaged between now and 2040 in the absence of the High-Speed rail project.

Considering the share of rail as a proportion of the combined rail/air market, we find the 2017 rail shares closely matched to shares found in international comparison for city pairs with similar rail journey times. By 2040, rail gains some share at the expense of air which is not explained by the rail journey times achieved in 2040. However, it in line with recent trends and with the expectation of relatively low growth for domestic air travel in Sweden.

Future forecast with High-Speed rail

The Sampers-based forecast shows demand levels for the High-Speed rail service of 4.9m annual trips for the Stockholm-Gothenburg corridor and 2.1m for the Stockholm to Malmö corridor. This represents a market share of 42% and 35% respectively. Rail as a proportion of the rail/air market is 80% and 60% respectively. This is relatively low compared with the levels that might be expected from international comparison given the projected journey times.

The material we have been able to examine suggests that the overall growth in demand once the High-Speed lines are in place is relatively high when compared with the level of journey time improvement. By contrast to the generated demand, we would regard the abstraction from other modes as modest.

The Sampers-based forecasts for demand between Stockholm and Copenhagen are very likely to be a significant underestimate. Analysis undertaken by TRV and our own analysis suggest that a level of 1.3m to 1.4m trips is more realistic.

Intermediate stations demand

While end-to-end demand has been a focus of our analysis, regional demand also forms an important part of the justification for the scheme. This includes both, demand between the key end station and smaller conurbations in between and demand between the smaller conurbations themselves. The size of this intermediate demand is an important consideration in the route planning, when, for example, a decision is required between a station in the centre or the outskirts of a town or between different option for stopping patterns.

Using a degree of judgement, we have allocated the projected regional demand at the intermediate stations to the two main routes from Stockholm to Gothenburg and Malmö respectively and compare this to the end-to-end demand to calculate a proportion of regional demand.

This showed that while demand at intermediate stations grows between the base year and the 2040 base situation, there is a drop in regional demand as a proportion of total demand between the two years. This may be a consequence of the land use patterns underlying these forecasts where the main growth is assumed to take place in the major cities, especially around Stockholm and/or changes assumed to train service patterns between the two years.

Once the High-Speed rail service is in place, there is a substantial increase in demand at intermediate stations but the increase for end-to-end demand is larger, resulting in a drop in regional demand as a proportion of total demand. This is consistent with the journey time improvements that are proportionately larger for end-to-end movements than for those involving intermediate stations.

Regional travel forms a much larger part of the demand for the Malmö route (excluding travel to Copenhagen) compared with the Gothenburg route, both in absolute terms and as a proportion of total demand. While both routes share demand at Norrköping, Linköping and Jönköping, there are three additional stops on the Malmö route (Värnamo, Hässelholm and Lund), while on the Gothenburg route High-Speed trains are only expected to stop at Borås.

No forecasts of travel from intermediate stations to Copenhagen have been provided. Our own analysis suggests that such intermediate movements may add a further 0.5m trips to the overall demand for the route from Stockholm to Copenhagen. This excludes movements between Malmö and Copenhagen which are local trips that will be little affected by the introduction of High-Speed rail services.

Of the modelled scenarios, the original HSR Reference scenario and RU2 are proving most attractive for intermediate stations while RU1, RU3 and RU4 are less attractive. The results for RU4 seem somewhat counterintuitive as the reintroduction of city centre stations at Linköping and Jönköping would be expected to increase demand from intermediate stations compared with RU2. We recommend further analysis on the model run for that scenario.

Additional analysis of forecasts provided by PwC, referenced as PwC forecast[1] in this document and our own indicative calculations showed similar proportions of intermediate demand. The underlying analysis for the PwC forecast was not available for review but we understand that the PwC analysis took a high-level view of the potential for intermediate stations demand overall rather than building up a forecast from demand for individual stations.

International comparisons

Available data on international comparisons indicates that both the overall demand levels forecast for the two corridors and the rail mode shares with High-Speed rail in place lie well within the range found in international literature.

Impact of COVID-19

The likely long-term impacts of the pandemic can only be understood through scenario testing at the moment and our recommendation is that such scenarios should be run through Sampers to examine the potential range of outcomes. Such scenarios should be developed through discussion and consultation with key stakeholders and may include a range along the following lines:

- A high scenario, where economic activity and behaviour rebounds relatively quickly, recovering its pre-virus levels of travel demand at some point during 2021 and there is no enduring impact on either the economy or travel behaviour. In effect this is represented by the current set of forecasts.
- A central scenario, where economic output regains its pre-virus level by the end of 2023. There is no enduring impact on travel behaviour and forecasts can be adjusted by modifying the economic input parameters.
- A low scenario, where economic output recovers more slowly, returning to its pre-virus peak by the end of 2025. This results in a more significant loss of business investment, more firm failures and persistently high unemployment as the economy undergoes significant restructuring. Trip making is reduces as a result of lower GDP levels. In addition, trip rates are reduced for all journey purposes as people work more from home, travel to fewer business meetings and undertake more online shopping.

These changes in behaviour are likely to have a more significant impact on shorter trips but will also affect the demand for long distance travel. For example, the possibility of homeworking may accelerate a trend for people to move out of larger conurbations in search for more affordable or

[1] PwC forecast (4 September 2015): Sweden Negotiation – Commercial Qualifications for High-Speed Trains in Sweden

higher quality housing. They may then commute over a longer distance once, twice or three times a week instead of undertaking a local commuting journey every day.

Overall view on the forecast

Our review has compared the Sampers-based demand forecasts against those from a PwC study of 2015 and Trafikverket's own alternative projections, referenced as TRV analysis[2] in this document. It should be noted that both the Sampers-based forecasts and TRV's analysis are based on the geographical definitions of Labour Market Regions, while the PwC forecasts probably used narrower geographical area definitions. Where possible we have also undertaken our own calculations for comparison.

Our review of available data suggests that all the projections used for demand growth from base to forecast year appear cautious when compared with expected GDP growth which is generally seen as a measure of economic activity which is the main driver for travel demand. The link between GDP growth and growth in the demand for travel appears weaker in the forecasts than the trends that have historically been seen in Sweden.

Stockholm to Gothenburg

Once a future year no-HSR position is established, Sampers predicts a relatively high level of generated demand as a result of the implementation of High-Speed rail but low levels of abstraction from other modes. Both the PwC forecast and the TRV analysis assume higher abstraction from air and car modes.

Projections for High-Speed rail demand range from 4.9m (Sampers) to 6.4m (TRV analysis). Our own indicative calculation using an elasticity-based approach returns projections in the range of 5.9m to 7.4m.

Taking the available evidence in the round, we would therefore regard the Sampers-based forecasts as conservative.

Stockholm to Malmö

Sampers predicts a similar proportion of generated demand in this corridor and low abstraction from other modes, with larger proportions suggested by both PwC forecast and TRV analysis. In this corridor, the PwC forecast for HSR demand is very similar to Sampers while the projection from the TRV analysis is again higher than both.

Projections for High-Speed rail demand range from 2.1m (Sampers and PwC forecast) to 2.9m (TRV analysis). Our own indicative calculation using an elasticity-based approach returns projections in the range of 3.4m to 5.2m, with even our lower estimate higher than that from other sources. We would therefore regard the Sampers-based forecasts as very conservative.

Stockholm to Copenhagen

It is clear from this review that travel to Copenhagen is not adequately represented in the Sampers projections and an alternative forecasting method is required. More realistic forecasts are available both from the PwC forecast and the TRV analysis with projections of 1.0m and 1.3m annual trips respectively. We have sought to add to this analysis by estimating an "envelope" of plausible forecasts for High-Speed rail demand between Stockholm and Copenhagen. This generated a range of 1.4m to 3.0m passengers. However, this analysis took no account of the "border effect" of travel to a different country.

International evidence on the "border" effect is difficult to find. Available data on long distance routes suggests that the "border effect" is quite significant, suggesting that the lower end of the envelope of forecasts of around 1.4m passengers for Stockholm to Copenhagen is more realistic. However, higher demand levels could be expected if the economic and cultural connections between Sweden and Denmark are stronger than those between the countries we have reviewed.

ok[2] TRV analysis: Trafikverket's own alternative projections from the market analysis and transfer effects

1. Introduction

1.1 Background to this study

In June 2020, the Swedish Government asked Trafikverket (TRV) to provide updated and supplementary information regarding new trunk lines for High-Speed trains for the Stockholm – Gothenburg and Stockholm – Malmö sections within a total investment framework of SEK 205 billion in 2017 prices. As part of this, an analysis of the effects on long- and short-distance passenger travel demand and effects on air traffic is required.

Work has been undertaken within Trafikverket to answer the questions based on the models and tools that the authority has at its disposal. This means that estimates for long-distance and short-distance travel as well as transfer effects on flights and car traffic were produced. Jacobs has been asked to undertake a review of the results produced by Trafikverket and to provide a second opinion on the forecast based on international experience. The main focus of the analysis is long-distance passenger travel as well as regional demand between the relations:

- Stockholm – Gothenburg;
- Stockholm – Malmö; and
- Stockholm – Copenhagen.

The brief includes examination of passenger numbers and transfer effects on flights and car traffic on these. In addition, a comparison with PwC forecast and a separate projection produced by Trafikverket outside the formal modelling framework should be undertaken.

We have undertaken the review in three main parts:

- Understanding the overall demand for travel between Stockholm and Gothenburg and between Stockholm and Malmö/Copenhagen;
- Analysing the key drivers of growth in demand from now to the forecast year; and
- Reviewing the share of demand that will be attracted by High-Speed rail.

Throughout the project we have been in close contact with Trafikverket to discuss available data and information and provide updates on progress.

1.2 The forecasting model

The demand forecasts provided by Trafikverket are based on the Swedish national transport model Sampers. The Sampers demand model predicts future demand levels by mode of transport, which are assigned to highway and public transport networks using EMME software. Key inputs to Sampers are changes in real income, fuel prices, employment and population. Future network changes are coded in the EMME assignment model. Two versions of Sampers were employed for this work with earlier forecasts relying on a 2014 base year and later forecasts using an updated 2017 base.

We have not undertaken a detailed review of the Sampers modelling system but have sought to understand its key inputs and drivers of the demand forecasts.

1.3 Comparison forecasts

As part of our review, we have examined two further sources:

- PwC Forecast: In 2015, PwC produced a report (”Kommersiella förutsättningar för höghastighetståg i Sverige”) which provided forecasts for High-Speed rail demand; and
- TRV analysis: In addition to the model-based forecasts, TRV have undertaken a separate analysis (”Marknadsanalys och möjliga överflyttningar från flyg och bil”) which produced some trend-based projections which draw on experience in other countries to inform assumptions about demand transfer to the new High-Speed lines.

We have provided some commentary on these projections and their comparison with the model-based forecasts.

1.4 Scenario naming

Different scenario names have been used in different sources to describe base year and forecast year scenarios and for alternatives with and without High-Speed Rail. To avoid confusion, we have adopted the following naming convention in this report:

- Base year scenarios are referred to as “2014 Base” or “2017 Base” as appropriate;
- Forecast year scenarios without the New Lines in place are referred to by the forecast year and “No HSR”;
- The Original High-Speed Rail scenario that is sometimes called ÖSU or UA is referred to as “HSR Reference Scenario”; and
- The new set of alternative alignment and service pattern scenarios is referred to by their names RU1 to RU4.

1.5 Structure of this report

Following this brief introduction, the remainder of this report is structured as follows:

- In chapter 2 we review present day demand patterns;
- Chapter 3 examines historical trends in travel demand in Sweden;
- In chapter 4 we analyse projected future demand without New Lines from the forecasting model Sampers;
- Chapter 5 presents our analysis of projected future demand with New Lines from the forecasting model Sampers;
- In chapter 6 we contrast the Sampers-based forecasts to the PwC forecast and TRV analysis and compare these to our own indicative projections;
- In chapter 7 we review available forecasts for demand at intermediate stations;
- Chapter 8 presents material from an international review of the High-Speed rail market; and
- Chapter 9 presents our overall view on the available forecasts.

Appendix A presents a bibliography with a listing of all material consulted in the preparation of this report.

2. Present Day Demand

2.1 Demand from and to Stockholm

In order to help us understand the reliability of any forecasts, we wanted to examine present day demand levels and patterns for the key origin-destination pairs of relevance for High-Speed rail. In particular, we wanted to understand how reliable the base year numbers are in the Sampers model used for forecasting.

Trafikverket have made available data on present day demand for a 2019 pre-Covid situation. Table 2.1 shows 2019 annual demand by mode for key destinations from Stockholm. This table provides data for the labour market regions of Stockholm, Malmö/Lund/Helsingborg and Gothenburg rather than just the cities.

Table 2.1: Passengers (millions) from Stockholm to a Number of Destinations, 2019, pre-Covid

2019 pre-Covid	Total	Air	Train	Bus	Car
Stockholm – Gothenburg/Borås LA	5.7	19%	40%	1%	39%
Stockholm – Malmö LA	3.6	39%	27%	1%	33%
Stockholm – Copenhagen	2.4	57%	13%	0%	30%

Source: Trafikverket

This shows total demand between Stockholm and the Gothenburg/Borås region of 5.7 million and between Stockholm and Malmö of 3.6 million passengers.

The derivation of actual long-distance travel demand by mode is never straightforward and requires the combination of data from a variety of sources, not all of which are strictly comparable. We understand from discussions with Trafikverket that most confidence can be attached to the air demand data which is derived from flight departure and destination data, with possibly the train data being the second most reliable. The car data is based on estimates derived from interview origin-destination surveys.

Table 2.2 shows total demand between Stockholm and the labour regions of Gothenburg/Borås and Malmö/Lund from the 2014 base of the Sampers forecasting model and Table 2.3 gives the same information for the 2017 base.

Table 2.2: Passengers (millions) from Stockholm to a Number of Destinations, Sampers 2014 Base

Sampers 2014 Base	Total	Air	Train	Bus	Car
Stockholm – Gothenburg/Borås LA	6.4	20%	33%	4%	43%
Stockholm – Malmö LA	3.5	32%	31%	5%	32%
Stockholm – Copenhagen	0.2	0%	100%	0%	0%

Source: Sampers forecasting model

Table 2.3: Passengers (millions) from Stockholm to a Number of Destinations, Sampers 2017 Base

Sampers 2017 Base	Total	Air	Train	Bus	Car
Stockholm – Gothenburg/Borås LA	6.6	18%	28%	4%	50%
Stockholm – Malmö LA	3.6	33%	26%	5%	35%
Stockholm – Copenhagen	0.2	0%	100%	0%	0%

Source: Sampers forecasting model

Table 2.1 gives a total of 5.7m passengers for Stockholm-Gothenburg/Borås for 2019. Table 2.2 gives 6.4m for Stockholm-Gothenburg/Borås for 2014 and Table 2.3 shows 6.6m for 2017. On mode share, all three data sources suggest a consistent share of 18% to 20% for air. Car shares are higher (and rail shares correspondingly lower) in the Sampers numbers compared to the 2019 observed data. This difference is more pronounced in the 2017-based Sampers data.

The totals for the Stockholm-Malmö/Lund corridor are closely matched between Table 2.1 (2019), Table 2.2 (2014 Sampers Base) and Table 2.3 (2017 Sampers Base) at around 3.6 to 3.8m. On mode share, the 2017 Sampers base matches the 2019 data more closely than the 2014 base, especially with regard to the rail share.

Both Table 2.2 and Table 2.3 indicate that demand to Copenhagen by all modes is not fully represented in the Sampers model.

We understand that the data in Table 2.1 includes transit passengers[3] for air. Trafikverket estimate that the transit passengers account for around 50% of the aviation market from Stockholm-Gothenburg, 30% for Stockholm-Malmö and 55% for Stockholm-Copenhagen.

For air and train, therefore, the numbers include all trips from and via Stockholm and their true origins are not known. The car numbers which are derived from origin-destination surveys include only those trips that originate in the Stockholm Labour Market Area. The Sampers numbers are understood to be derived from the model's origin-destination matrices for the Stockholm Region and the respective Labour Market Areas and do not include transit trips.

The information provided appears to suggest that the Sampers base year scenarios contains the right order of magnitude of demand from which to forecast growth on the main corridors from Stockholm to Malmö and from Stockholm to Gothenburg. However, on the route from Stockholm to Copenhagen, Sampers only contains rail demand and neither demand by air or by car.. Furthermore, we understand from the documentation we have received that the forecasting inputs assume no growth in that market from the base year position.

2.2 Other international demand

Trafikverket have made available some additional information on the international travel market that may become part of the scope for the High-Speed rail proposals. The most important is connections to Copenhagen and beyond via the Öresund crossing.

For journeys from Sweden to Copenhagen Kastrup Airport, trains have a market share of over 75% today. The airport is served by frequent direct trains from large parts of southern Sweden and a large proportion of the trips attracted to Kastrup will be from that area. These direct connections extend as far as Jönköping and Östergötland counties and offer better connectivity for these areas to Kastrup than to Stockholm Arlanda. Kastrup therefore is the main hub airport for large parts of southern Sweden.

The other international travel market that may be in scope for High-Speed rail is the direct travel between Sweden and Germany that currently takes place by ferry. This could become attractive for rail travel once the planned Fehmarn Belt connection opens towards the end of this decade and could attract travel from both southern Sweden and Denmark.

Data made available by Trafikverket suggests that the combined travel market from Sweden and Denmark to European destinations in the UK, the Netherlands, Belgium, France and northern Germany which could potentially be in scope for longer distance High-Speed rail services amounts to around 8.5 million trips today.

We understand that the current demand modelling does not capture the potential to attract some of this demand to High-Speed rail.

[3] For example a flight from Arlanda to New York via Kastrup would be included in the Stockholm-Copenhagen total.

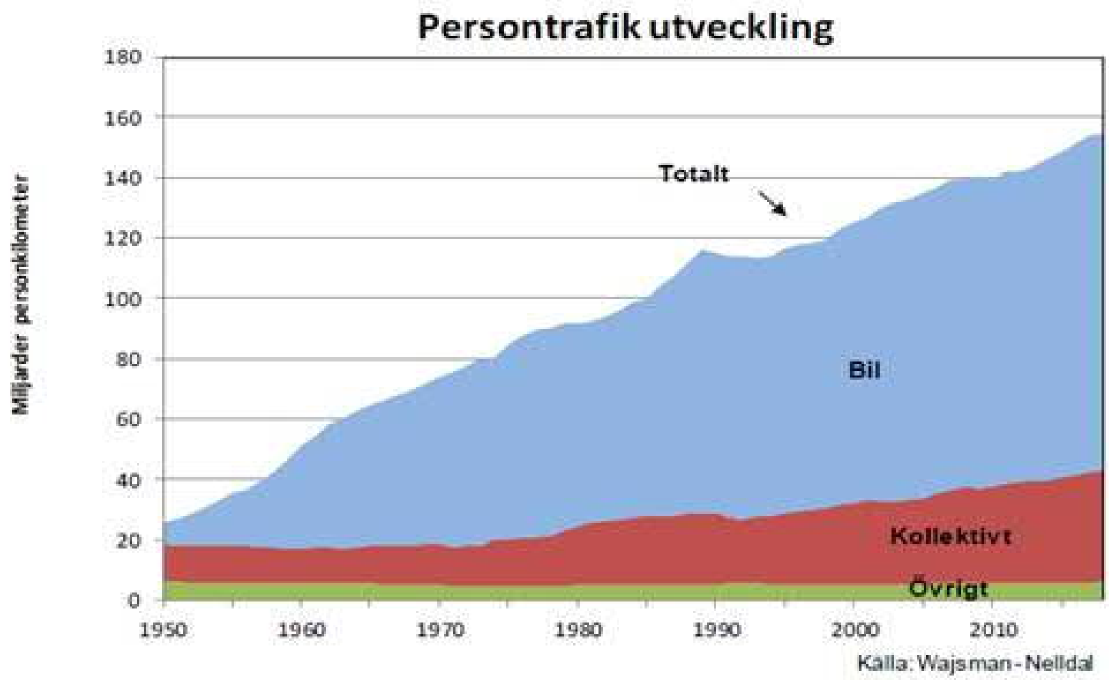
3. Historical Trends in Travel Demand

3.1 Overall travel demand growth

As part of understanding the realism of demand forecast for the future, we wanted to understand past trends in travel demand in Sweden.

Figure 3.1 shows historical trends in travel demand in Sweden since 1950, while Figure 3.2 shows growth in the demand for long distance public transport since 1950.

Figure 3.1: Travel Demand over Time



Source: KTH Report for Trafikverket, 2019

Values are presented in millions of person-kilometres for the past seventy years. Notably, the trend for increased travel has fallen primarily to car use, rising from a quarter of all travel in 1950 to nearly 80% by the mid-2010's.

Public transport use, which accounted for around half of person-kilometres travelled in 1950, accounts for less than a quarter now. Active modes, such as walking and cycling have remained largely static, perhaps with a marginal decline over the period.

The chart below shows the trend between various long-distance public transport modes since 1950. Generally public transport use has grown significantly since 1950, though only at a fraction of the rate of growth experienced by car for all travel.

Figure 3.2: Long Distance Public Transport Demand over Time

Source: KTH Report for Trafikverket, 2019

Bus use appeared to peak around 1975, and after some more depressed usage in subsequent decades, has marginally surpassed this peak in recent times as new long-distance coach services were introduced in the market by companies like Swebus Express and Flixbus. The latest data shows bus use plateauing at around 2.3 million passenger kilometres.

Rail use is currently double the levels seen in the 1950s. However, the growth has been erratic, with several periods of temporary declines producing troughs in 1970 and the early 1990s. The reasons for this fluctuation could be numerous, including reaction to the economic climate, and periods of decline in punctuality. Later increases in rail usage are probably thanks to recent efforts to speed up inter-city travel with the introduction of the X2000 service, making rail more competitive with air.

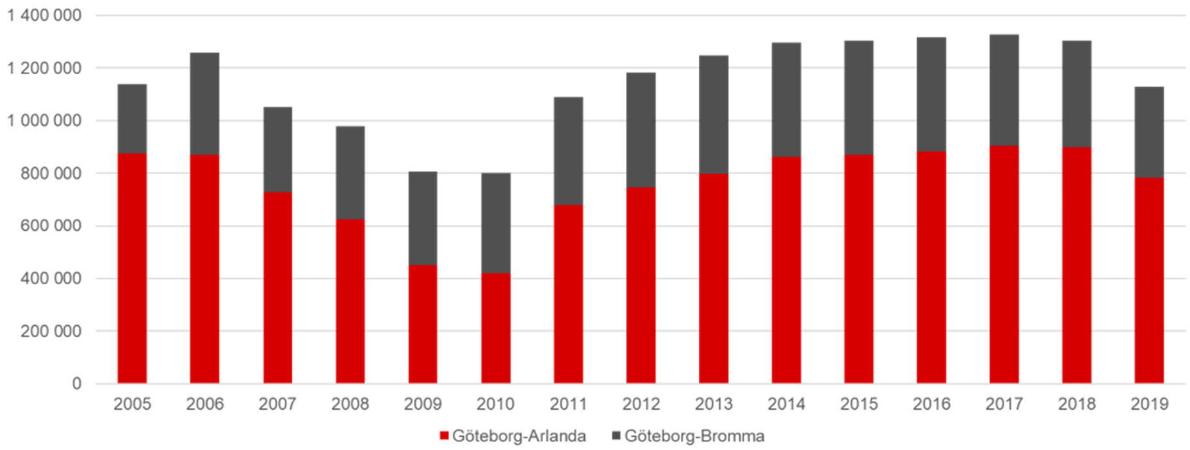
Air use grew sharply between 1950 and 1990 before competition, presumably primarily from rail, started to lessen the demand for the domestic flights graphed above, plateauing from around 1990 onwards. Even without the advent of High-Speed rail, railways have started to out-perform other public transport modes in the long-distance sector, with over 30% growth between 1995 and 2015.

3.2 Recent trends in air demand

Trafikverket have provided a number of trend graphs for domestic air demand for a number of domestic destinations from Stockholm including Gothenburg, Malmö, Ängelholm/Helsingborg and Kalmar as well as international demand to Copenhagen. The overall trends are similar for all these connections, showing a decrease between 2005 and 2010, followed by growth between 2010 and 2017 which coincided with significant punctuality problems on trains. Since 2017, air demand has declined on all these routes.

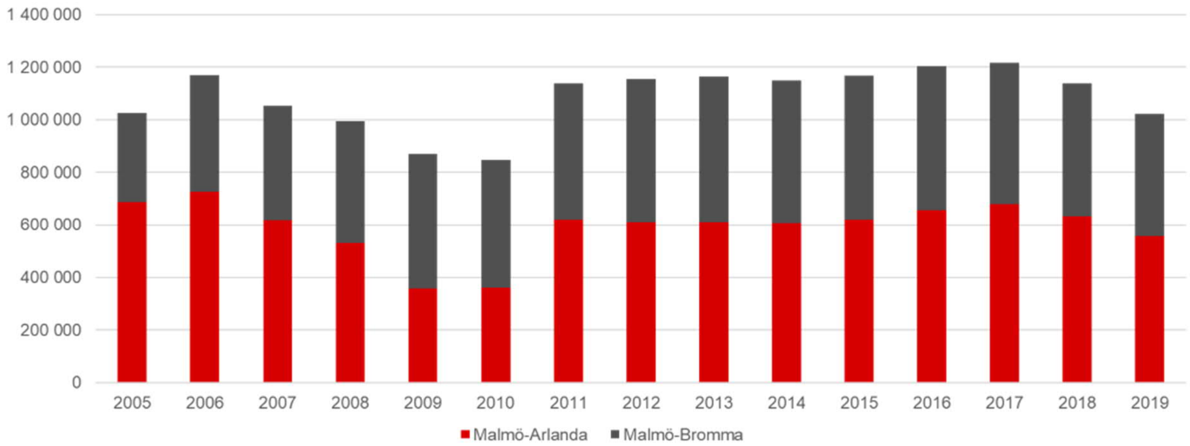
In Figure 3.3 to Figure 3.5 we reproduce the graphs provided for the key routes from Stockholm to Gothenburg, Malmö and Copenhagen respectively.

Figure 3.3: Air Demand Trend 2005-2019, Stockholm-Gothenburg



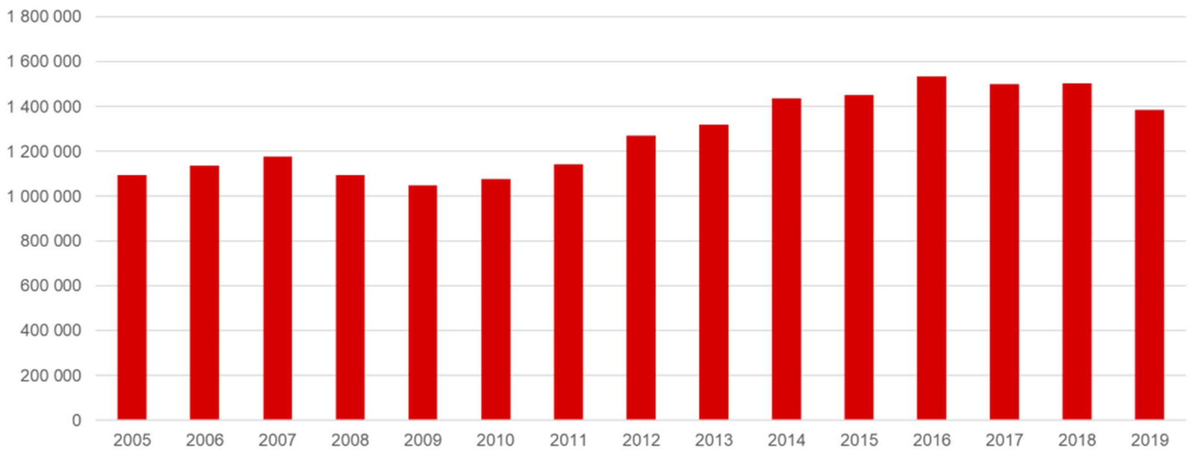
Source: Trafikverket

Figure 3.4: Air Demand Trend 2005-2019, Stockholm-Malmö



Source: Trafikverket

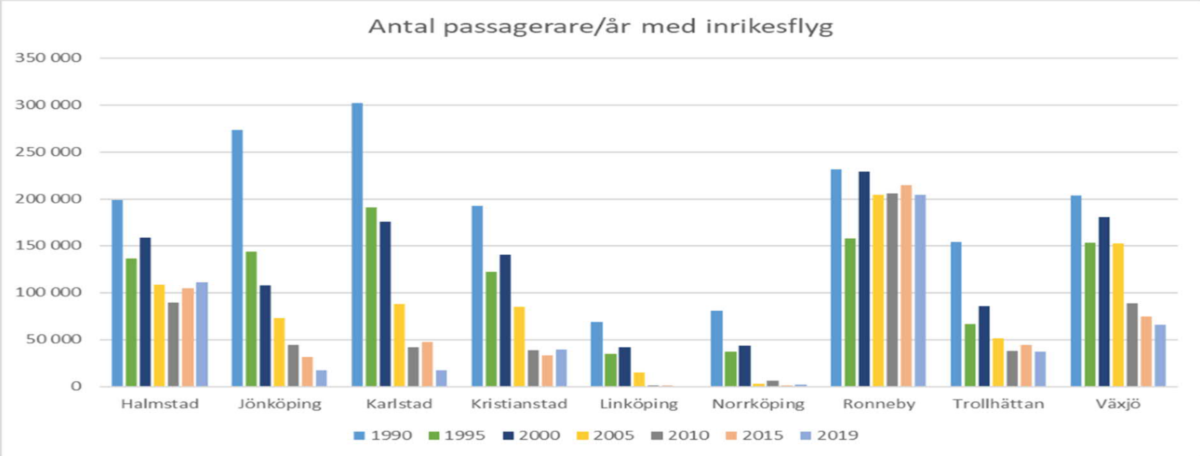
Figure 3.5: Air Demand Trend 2005-2019, Stockholm-Copenhagen



Source: Trafikverket

For regional connections from Stockholm, there has been a sharp decline in air demand for most destinations as shown in Figure 3.6. These trends can be attributed to significant improvements in the rail service over that period, in particular with the introduction of the X2000 service. The exception to this trend is demand for travel to Ronneby which lies close to the south coast of Sweden and is not served by the main rail corridors that have been improved.

Figure 3.6: Air Passengers from Stockholm to regional Destinations, 1990 to 2019



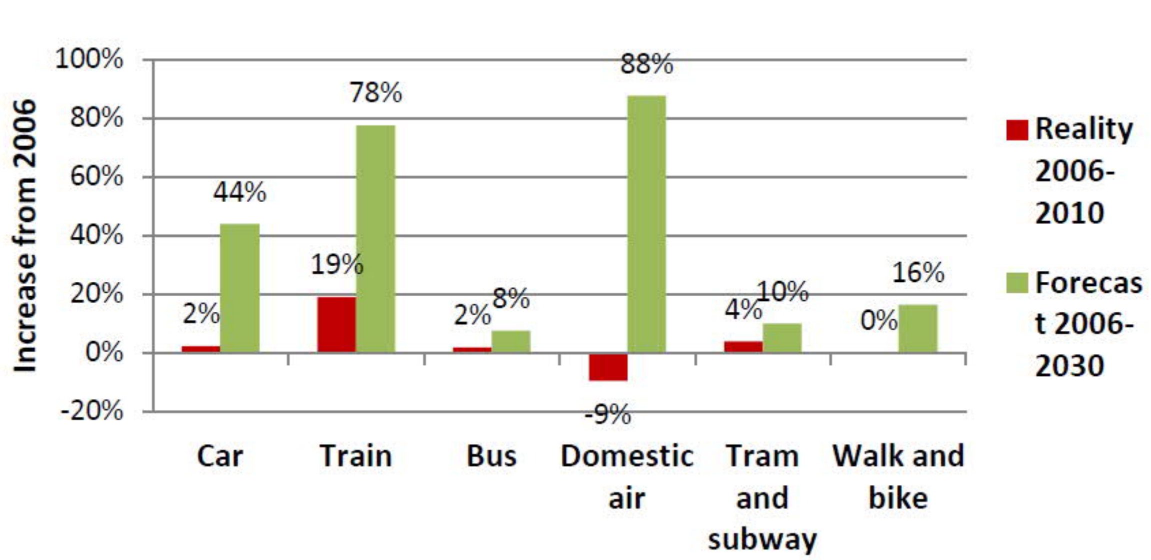
Source: Trafikverket

All the available data shows that Aviation was hit particularly hard by the deep economic recession prior to 2010, while some improvements in rail journey times have reduced the demand for domestic flights since then.

3.3 Past forecasting performance

Although from a 2012 Trafikverket document, the chart in Figure 3.7 below is nevertheless instructive with regard to past forecasting performance. It compares the overall growth in travel by mode as recorded between 2006 and 2010, with the total growth forecast between 2006 and 2030.

Figure 3.7: Historical and forecast Growth by Mode



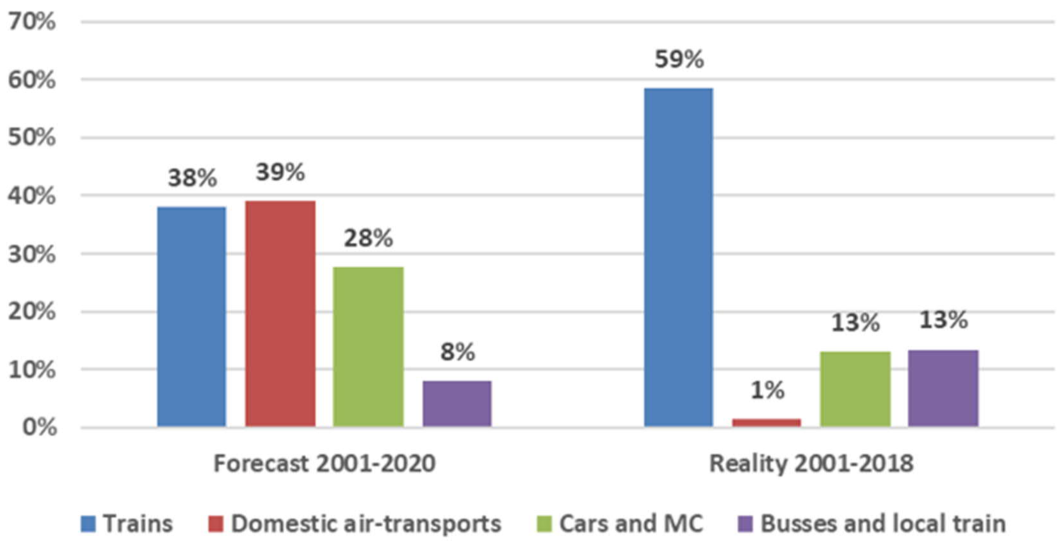
Source: High-Speed railways and expansion of existing trunk lines for the sections Stockholm–Gothenburg/Malmö

The forecast period is six times longer than the observed period; it is thus unsurprising that the magnitude of growth forecast is a many-fold increase from that in the four-year observed period. The comparisons between the observed (4-year) and forecast (24-year) figures are not unrealistic for train, bus and subway / tram.

For cars, the very slow growth observed over the period may point an over-estimation in predictions to 2030, while for domestic air a decrease was recorded. However, the comparison of this relatively short observed timeframe with forecasts is to be viewed with caution, particularly as the observed years include a period of severe economic recession that began in much of the world in 2008.

Figure 3.8 below shows the predicted versus observed growth in passenger traffic by mode for the 17-19 year period commencing in 2001.

Figure 3.8: Passenger Traffic Growth from 2001: Forecast and Outturn



Source: International passenger railway traffic – a new challenge – the "Frankfurt Presentation" by Lennart Lennefors

Given the long forecast period, the predictions for local trains and buses are of the correct magnitude, and the shortfall may be due to an under-estimation of the degree to which a shift from car towards public transport occurred in the early part of the 21st century in more developed countries.

This is echoed in the over-estimation of the degree to which car use would grow in the same period, estimated at around double the rate experienced in reality. Rail (medium and long distance) and domestic flights appear to have experienced a mode shift from the latter to the former.

In summary, we conclude that since 2001 rail demand has increased substantially and at a much higher rate than expected. This has been mainly at the expense of domestic air and car demand.

3.4 Main drivers for past trends in travel demand

A generally accepted principle of travel demand across the world is that there is a clear link between the growth in GDP and the growth in the demand for travel. This is true in most countries and contexts: More economic activity leads to more travel. Travel demand growth is often observed to be directly proportional to economic growth. This link can be expressed as an elasticity and in many contexts, the elasticity lies at or above 1: for every 1% growth in GDP, the growth in travel demand is 1% or more than 1%[4].

This has been found in studies in a number of countries as well as meta-studies using world-wide evidence. We have found no literature on the subject specific to the travel market in Sweden but we have examined past GDP growth and compared it to available data on travel demand growth. World Bank data in Figure 3.9 shows the real GDP growth in Sweden since 1950.

[4] In the UK, demand for rail travel has significantly outstripped GDP growth since the early 1990s and the UK Passenger Demand Forecasting Handbook quotes demand elasticities with regard to GDP above +1.0 for non-commuting demands in most markets

Figure 3.9: Real GDP in Sweden at constant National Prices

Source: World Bank

On average, this amounts to a growth in real GDP per annum since 1950 of 2.66%. This may be compared to the approximate growth in total travel demand since 1950 from Figure 3.1, which gives annual growth of some 2.76%5 per annum on average. From this we can calculate an approximate travel demand/GDP elasticity of +1.04.

If we look at the approximate growth in long distance Public Transport travel demand since 1950 from Figure 3.2, we calculate annual average growth of approximately 1.84%[5], which gives a long distance public transport demand/GDP elasticity of +0.7. While no data is available on the growth trend for long distance car demand, it is likely that, in line with Figure 3.9 on overall demand, this has also grown at significantly higher rates than the other modes. Thus, if car demand were included, it is likely that the elasticity of long-distance total demand to GDP would increase closer towards +1.0 in line with findings elsewhere.

[5] Calculated from figures read off the graph

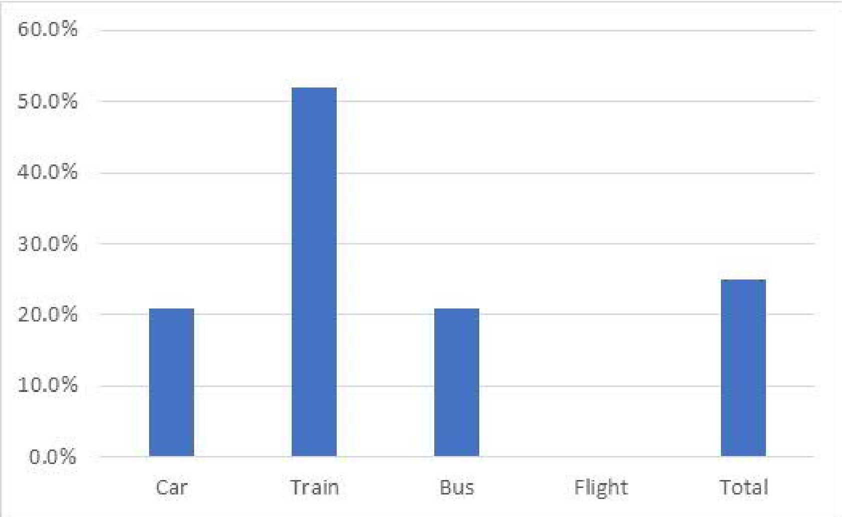
4. Projected Future Demand without New Lines (Sampers)

4.1 Overall demand forecasts

Having established an understanding of the base year situation and past trends in travel demand growth by mode, we now turn our attention to forecasts in the absence of new High-Speed rail lines.

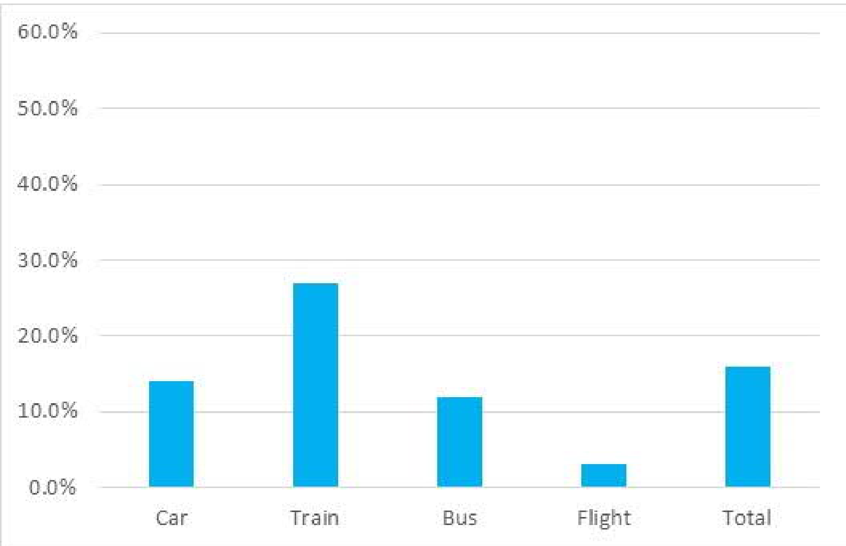
Figure 4.1 and Figure 4.2 show the forecast change in long-distance travel by mode for the periods 2017-2040 and 2040 to 2065 respectively.

Figure 4.1: Forecast Change in long-Distance Travel by Mode, 2017-2040



Source: Jacobs analysis of Sampers data

Figure 4.2: Forecast Change in long-Distance Travel by Mode, 2040-2065



Source: Jacobs analysis of Sampers data

The total increase in travel by all modes is around 25% to 2040 with further growth of 16% from 2040 to 2065. The increase is not split equitably between modes. Notably, flight travel for the domestic market is assumed to be completely static, with only a slight rise in the years beyond 2040. This would appear to be borne out by past trends whereby growth in domestic travel has flattened out, though this did include a period of deep economic recession.

Car and bus travel are assumed to grow by around the average in both cases, with slightly weaker bus growth in later years of 12% versus car growth of 14% between 2040 and 2065.

For longer distance travel, therefore, increases in rail travel are assumed to dominate, even without investment in High-Speed. This reflects a trend whereby mode share has been increasing for long-distance rail at the expense of air travel. Rail has been benefitting from both capacity and speed increases in recent times.

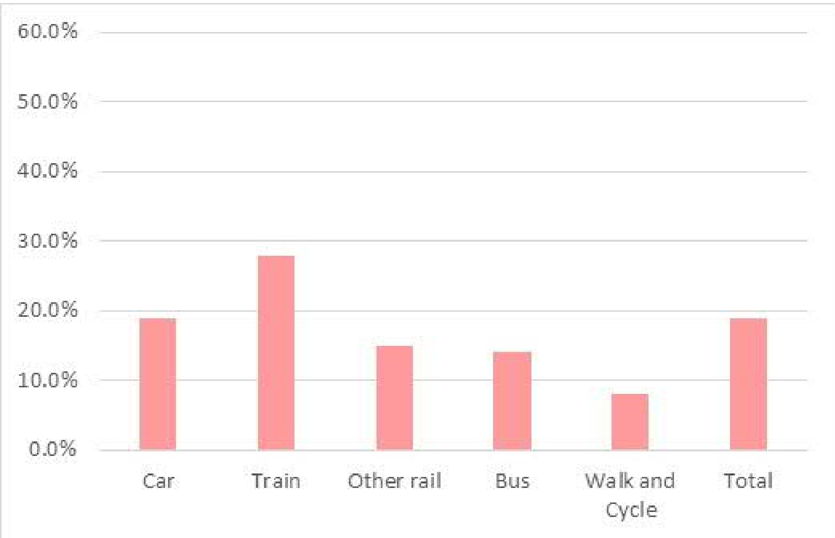
Overall, the division of growth between modes is largely the same in both the early future (to 2040) and late future (2065) forecasts.

Figure 4.3 Figure 4.4 show the forecast change in regional travel by mode for the periods 2017-2040 and 2040 to 2065 respectively.

Figure 4.3: Forecast Change regional Travel by Mode, 2017-2040

Source: Jacobs analysis of Sampers data

Figure 4.4: Forecast Change regional Travel by Mode, 2040-2065



Source: Jacobs analysis of Sampers data

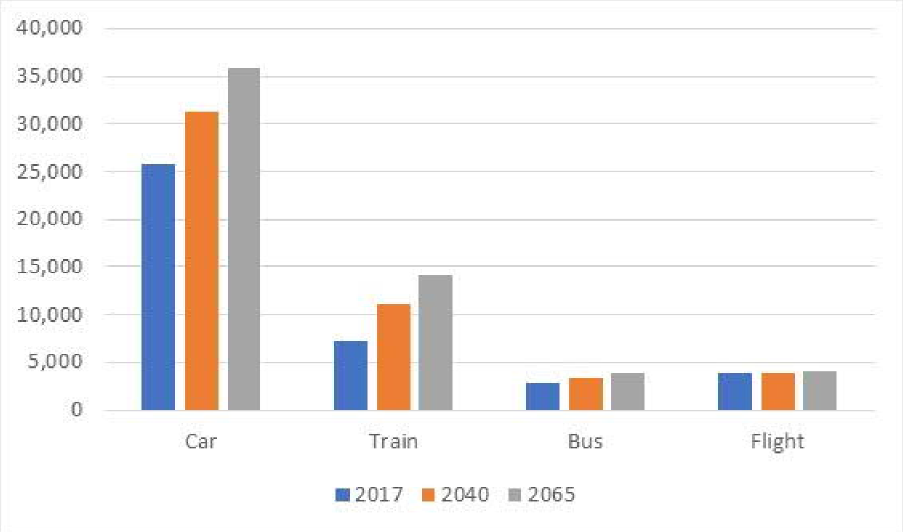
Here the overall forecast increase in travel demand by all modes is around 30% to 2040 with further growth of 19% between 2040 and 2065.

Train again shows the highest level of growth with car demand growing at about the average level. Other rail, which includes subway and tram services in urban areas, grows above the average to 2040 but below average between 2040 and 2065. We do not know the background to this but assume that the forecasting assumptions include investment in urban rail between 2017 and 2040 but not after 2040.

All other modes grow below the average for all modes in both forecasting periods.

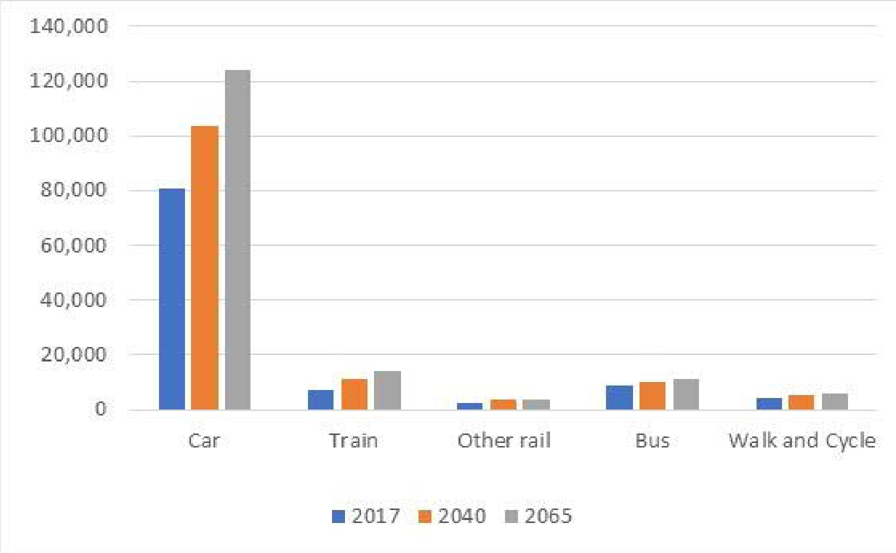
Figure 4.5 to Figure 4.7 show long-distance, regional and total distance travelled by mode.

Figure 4.5: Long-Distance Travel Kilometres Mode



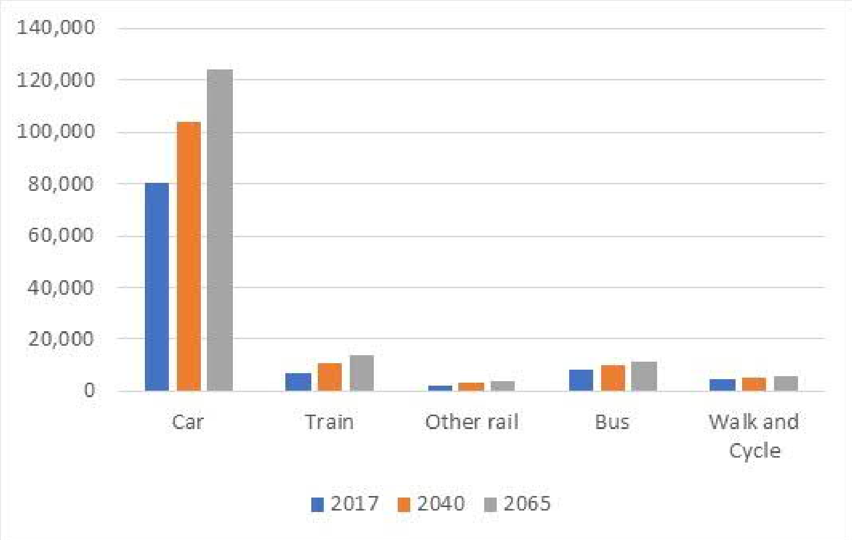
Source: Jacobs analysis of Sampers data

Figure 4.6: Regional Travel Kilometres Mode



Source: Jacobs analysis of Sampers data

Figure 4.7: Total Travel Kilometres Mode



Source: Jacobs analysis of Sampers data

Trends for long-distance travel growth by mode have been discussed, but these charts make clear the expected continuing dominance of car as a mode of transport for this market. However, the train makes proportionally more gains and swings the mode share away from car. Buses and flights are a comparatively smaller part of the long-distance market (though flights play a more important part in the High-Speed rail corridors) and have little influence on overall growth in the forecasts.

At the regional level, trends in car and train travel are similar to that for long-distance travel – albeit with far more car dominance in all three forecast years. Other rail, which includes subway and tram services in urban areas, also shows a similar trend. Bus travel is forecast to grow marginally more strongly than in the long-distance market.

4.2 2040 demand forecasts for the High-Speed rail corridors

Table 4.1 and Table 4.2 show total demand between Stockholm and the labour regions of Gothenburg/Borås and Malmö/Lund in the 2040 No HSR forecast from the Sampers forecasting model together with overall and annual average growth rates.

Table 4.1: Sampers Forecast (millions) Stockholm-Gothenburg/Borås, 2017-2040

Sampers Forecast	2017 Base	2040 No HSR	Growth over 23 years	Average annual growth
Car	3.3	5.2	58.0%	2.0%
Bus	0.3	0.4	46.4%	1.7%
Air	1.2	1.3	15.4%	0.6%
Train	1.9	2.9	55.9%	1.9%
Total	6.6	9.9	49.2%	1.8%

Source: Jacobs analysis of Sampers data

Table 4.2: Sampers Forecast (millions) Stockholm-Malmö/Lund, 2017-2040

Sampers Forecast	2017 Base	2040 No HSR	Growth over 23 years	Average annual growth
Car	1.4	2.3	70.8%	2.4%
Bus	0.2	0.3	52.6%	1.9%
Air	1.3	1.5	14.1%	0.6%
Train	0.8	1.3	62.8%	2.1%
Total	3.6	5.4	48.1%	1.7%

Source: Jacobs analysis of Sampers data

In the both corridors, with no rail improvements, car demand grows more strongly, closely followed by rail and bus, though bus demand is immaterial in the overall picture.

Air growth is assumed to be the lowest of all modes, at 0.6%, which would appear intuitive given the historically slower growth in domestic air travel as a mode share of the national long-distance travel market. In fact, domestic air demand has experienced a decrease of 12% from 2017 to 2019 with a further decrease obesrved in the pre-Covid first two months of 2020.

In absolute terms, given the variable popularity of each mode, the contribution to the absolute growth in passenger numbers over the 23-year period gives a different picture. In the Stockholm and Gothenburg corridor, some 59% of all growth is catered for by car, with 32% by rail, with the rest distributed between air and bus. The Stockholm and Malmö corridor shows 56% of the growth by car with 28% attributed to rail.

These differential growth rates lead to changes in the modal shares as illustrated in Table 4.3 and Table 4.4.

Table 4.3: Sampers Forecast Mode Shares Stockholm-Gothenburg/Borås, 2017-2040

Sampers Forecast	2017 Base	2040 No HSR
Car	50%	53%
Bus	4%	4%
Air	18%	14%
Train	28%	30%
Total	100%	100%

Source: Jacobs analysis of Sampers data

Table 4.4: Sampers Forecast Mode Shares Stockholm-Malmö/Lund, 2017-2040

Sampers Forecast	2017 Base	2040 No HSR
Car	38%	44%
Bus	5%	5%
Air	35%	27%
Train	22%	24%
Total	100%	100%

Source: Jacobs analysis of Sampers data

In both corridors, the share of car travel increases and the share of air travel decreases. The rail share increases slightly in both corridors.

It is also instructive to consider the air/rail shares for the two corridors in the 2017 model base year and the 2040 forecast as presented in Table 4.5.

Table 4.5: 2017 and 2040 Sampers Air/Rail Shares

Year	Route	Air Share	Rail Share
2017	Stockholm-Gothenburg	38%	62%
	Stockholm-Malmö	62%	38%
2040	Stockholm-Gothenburg	32%	68%
	Stockholm-Malmö	53%	47%

Source: Jacobs interpretation of Sampers data

This shows a dominance of rail in the Stockholm-Gothenburg corridor and of air in the Stockholm-Malmö corridor. The 2017 rail shares are closely matched to shares found in international comparison for city pairs with similar rail journey times. In both cases, rail gains some share at the expense of air over the forecasting period which is not explained by the rail journey times achieved in 2040. However, it in line with recent trends and with the expectation of relatively low growth for domestic air travel in Sweden.

4.3 Key drivers of forecasts

The table below indicates the assumptions made about the changes in economic parameters between 2017, 2040 and 2065.

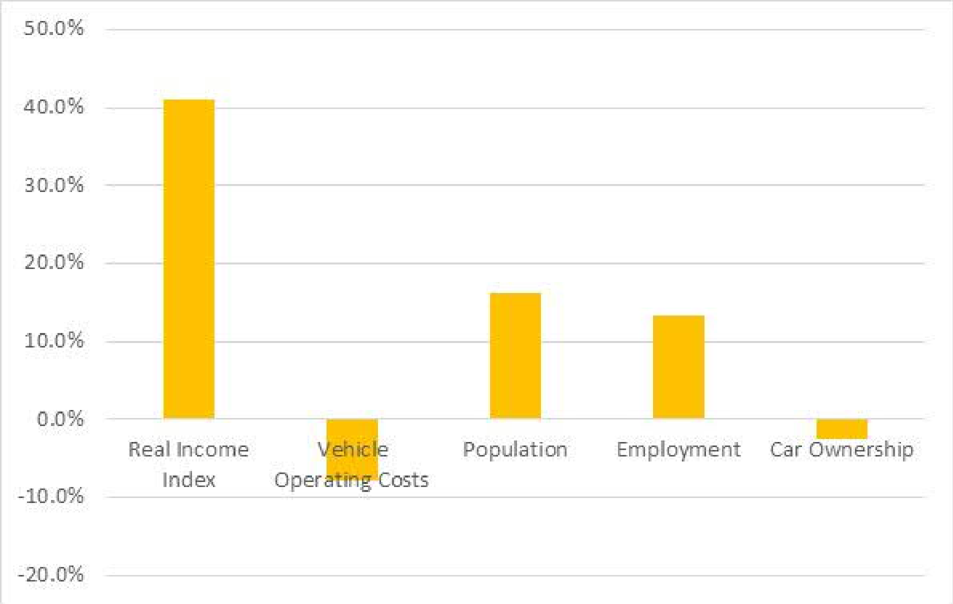
Table 4.6: Economic Parameters in Sampers

Förutsättning	2017	2040	2065	Rel utv 2017-2040		Rel utv 2040-2065		Effekt**
				Perioden	Årligen	Perioden	Årligen	
Realinkomstutv	1	1,41	2,04	41%	1,5%	45%	1,5%	Ökning
Körkostnad bil kr/km	2,03 kr	1,87 kr	1,87 kr	-8%	-0,4%	0%	0,0%	Ökning
Befolkning*	9 978 422	11 593 995	12 611 256	16%	0,6%	9%	0,3%	Ökning
Förvärvsarbetande*	4 833 280	5 476 300	5 898 082	13%	0,5%	8%	0,3%	Ökning
Bilar/capita	0,41	0,40	0,40	-2%	-0,1%	0%	0,0%	Minskning

Source: Prognos för persontrafiken 2040 - Trafikverkets Basprognoser 2020-06-15

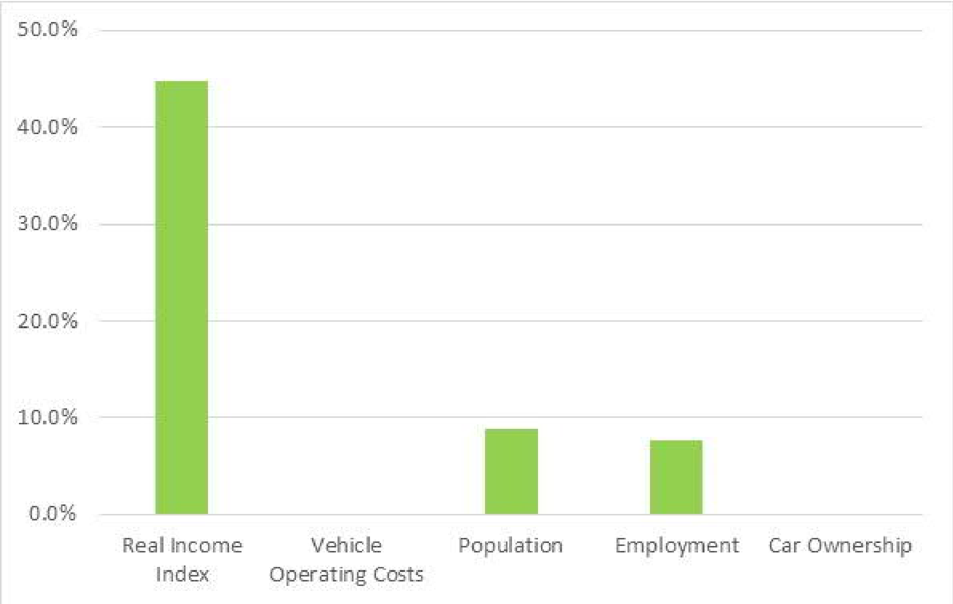
These changes are shown graphically in Figure 4.8 and Figure 4.9 for the period 2017-2040 and 2040-2060 respectively.

Figure 4.8: Forecast Change in economic Inputs, 2017-2040



Source: Jacobs analysis of Sampers input data

Figure 4.9: Forecast Change in economic Inputs, 2040-2065



Source: Jacobs analysis of Sampers input data

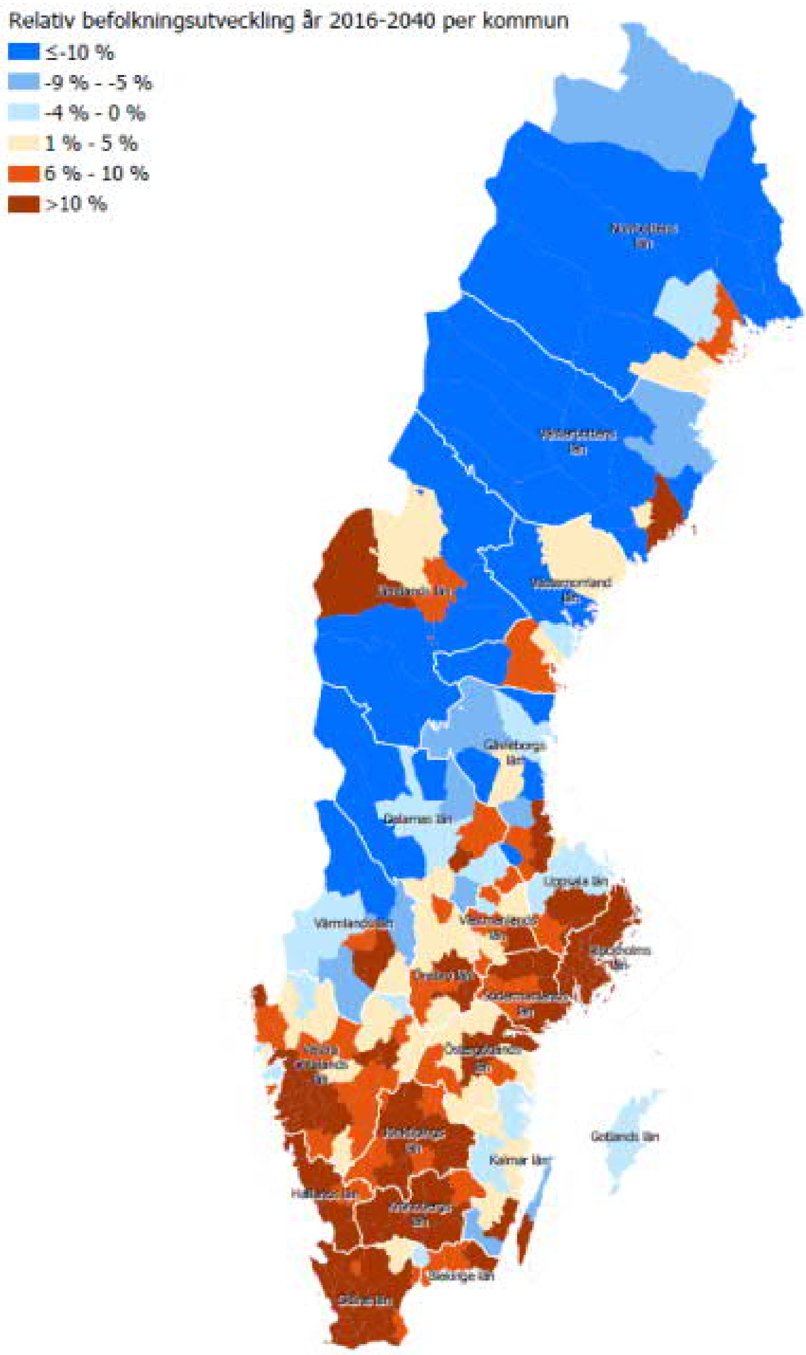
The Real Income Index is assumed to increase at a steady rate of 1.5% per year, with the effect of increasing overall transport demand. We have not undertaken any external verification of this, but this looks consistent with the long-term GDP growth trend in Sweden. Vehicle Operating costs on the other hand are forecast to fall between 2017 and 2040 by 8% total, before plateauing to 2065. This has the effect of shifting demand away from public transport demand.

More significant falls in vehicle operating costs than those assumed in Sampers could be expected as a result of a large-scale switch to electric cars unless there is a compensating change to the tax regime. At the moment, governments wish to encourage the switch from fossil fuel-based transportation and are reluctant to make such changes. However, fuel tax is a very significant source of government revenue and it is reasonable to assume that in the longer term, changes in taxation would be made to maintain this income stream from car travel.

Car ownership is forecasted to be almost static over the period, with a marginal fall from 0.41 to 0.40 vehicles per person between 2017 and 2040. This would be expected to have a very marginal impact on the growth rate of public transport demand.

Sweden's population is assumed to increase from 10.0m today to 11.6m in 2040 and 12.6m in 2065, which represents a growth rate of 0.7% per year to 2040, and a lesser rate of 0.3% per year to 2065. However, more important than overall population increase is the distribution of this change as shown in Figure 4.10.

Figure 4.10: Distribution of Population Growth in Sweden, 2016-2040



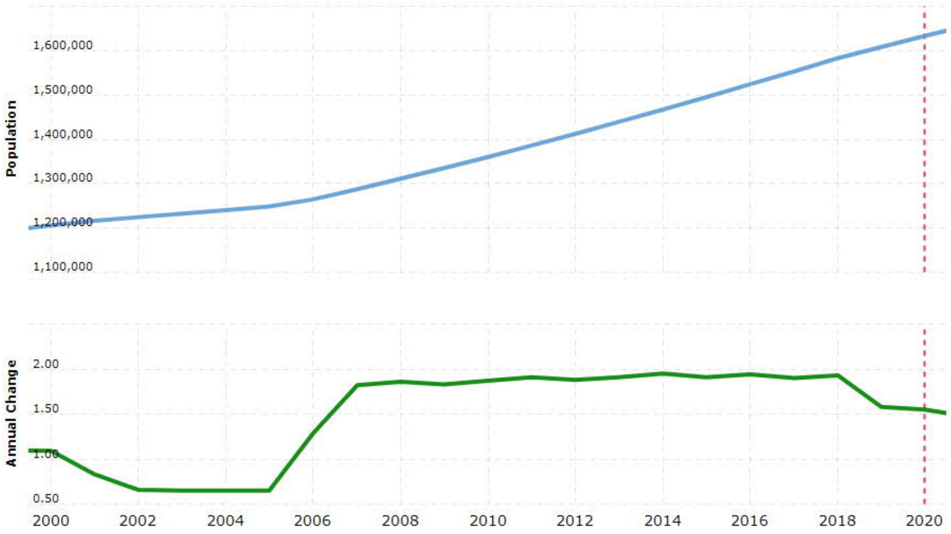
Source: Prognos för persontrafiken 2040 - Trafikverkets Basprognoser 2020-06-15

This shows a profound shift in population from the north of Sweden to the south, with particularly high growth in the corridors served by the proposed High-Speed rail lines. While some areas in the north experience a decline in population, the projected growth rates from 2000 to 2040 for key conurbations in the south are:

- 59% for the Stockholm county;
- 43% for Skåne county (which contains Malmö); and
- 28% for Västra Götaland county (which contains Gothenburg).

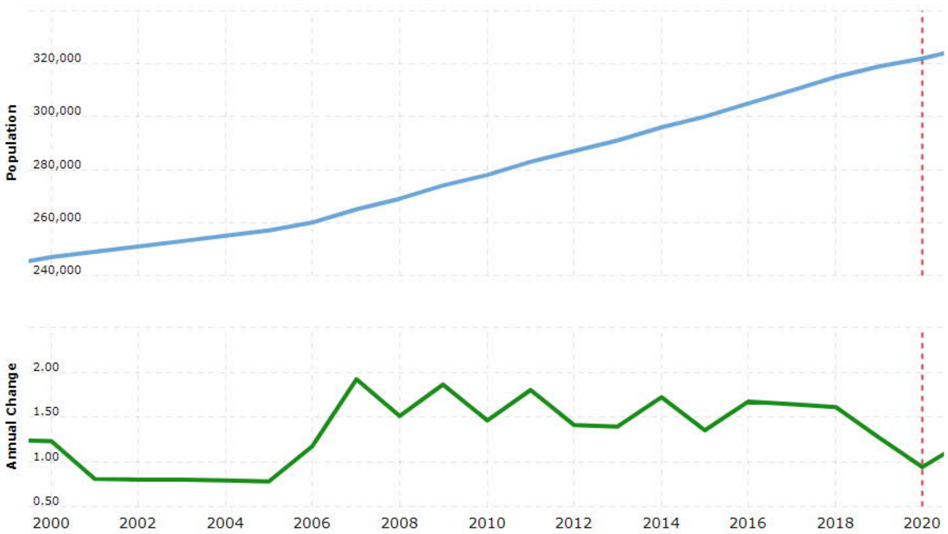
As we are now half-way through the period from 2000 to 2040, it is instructive to consider what growth has actually taken place in the last 20 years. United Nations population data is shown in Figure 4.11 to Figure 4.13 for the three conurbations.

Figure 4.11: Population Growth 2000-2020, Stockholm Metropolitan Area



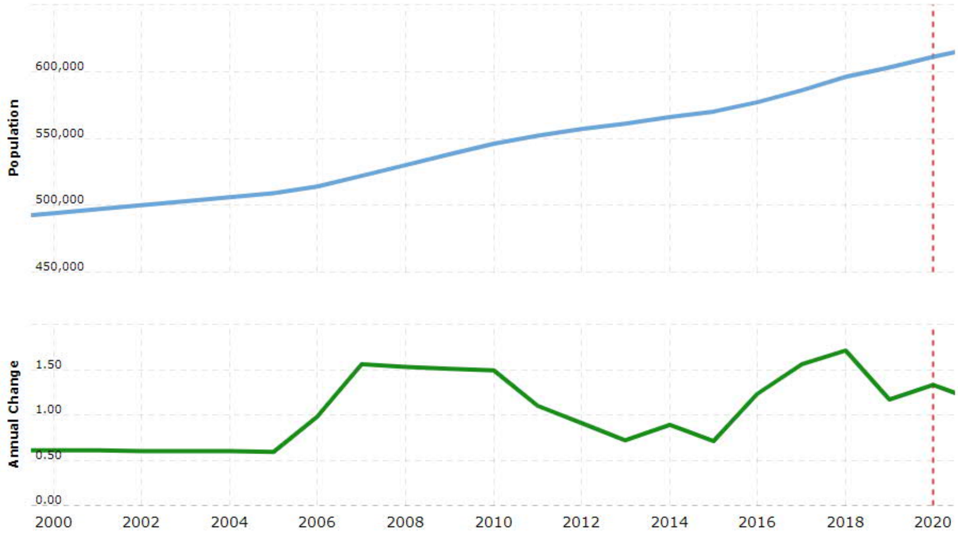
Source: United Nations - World Population Prospects

Figure 4.12: Population Growth 2000-2020, Malmö



Source: United Nations - World Population Prospects

Figure 4.13: Population Growth 2000-2020, Gothenburg



Source: United Nations - World Population Prospects

From this we can calculate actual growth from 2000 to 2020 of:

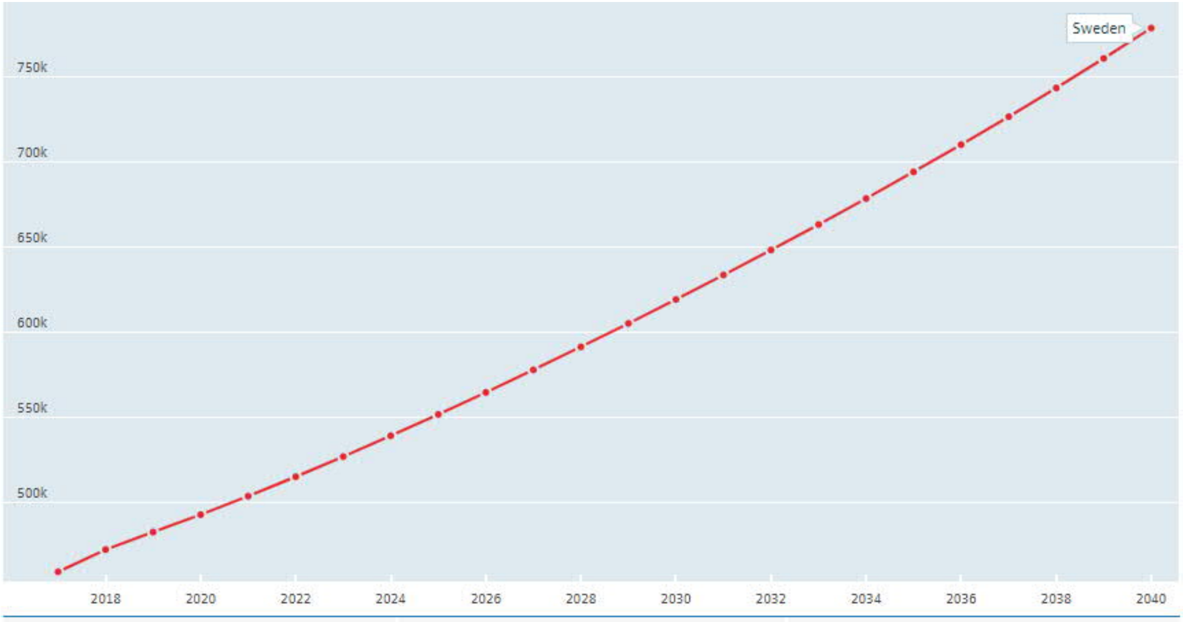
- 35% for the Stockholm Metropolitan Area;
- 30% for Malmö; and
- 23% for Gothenburg.

Against these historical trends, the growth forecasts assumed in Sampers do not seem excessive.

Employment is forecast to grow at a slower rate of 0.5% to 2040, and then matches the slower population growth rate of 0.3% thereafter. The way in which the rate changes relative to population may be an outcome of changing demographics with an ageing population in Sweden. Overall, both population and employment growth would contribute to a positive trend for transport demand, though the different rates of population and employment increase would be expected to change growth rates differently by journey purpose.

While GDP growth is not provided as one of the inputs to the Sampers forecasts, the combination of real income growth and growth in population and employment could be expected to provide a close proxy for GDP growth. On that basis we may expect GDP growth to 2040 of between 2.0% and 2.2% which may be compared to projections by the OECD as shown in Figure 4.14 which give annual average growth of 2.3%. These growth rates are lower than the 2.7% experienced since 1950 (Figure 3.9) which is to be expected from a highly developed economy.

Figure 4.14: Projected GDP Growth in Sweden 2017-2040



Source: OECD

At a very high level, we can take a GDP growth rate of around 2.1% per annum as representative of the Sampers input, and compare this against the Sampers demand growth forecast for 2017-2040 without new lines (all modes):

- 49% for Stockholm-Gothenburg, equivalent to 1.8% per annum; and
- 48% for Stockholm-Malmö, equivalent to 1.7% per annum.

This would imply a demand/GDP elasticity of +0.86 for the Stockholm to Gothenburg demand and +0.81 for the Stockholm to Malmö demand. These elasticities are slightly below those derived for the period from 1950 to present day. In addition to GDP growth, demand for travel in the High-Speed rail corridors will also be affected by the projected drop in vehicle operating costs and the shift in population towards the south of Sweden. However, similar trends may have been implicit in the GDP elasticities we have calculated for the period since 1950.

The focus on GDP growth in this context is appropriate as this is generally seen as a good indicator of changes in the demand for travel. While other factors such as car ownership, price escalation for fuel or public transport fares, service levels and journey times also have an influence, they tend to affect the balance between travel modes rather than the overall demand for travel. Growth in employment or population are also important but the growth in GDP encompasses both population growth and the growth in economic output per capita and is therefore a good measure of overall economic activity which in turn drives the demand for travel. Even if growth rates may differ between journey purposes, GDP growth is still a good indicator of overall demand changes for a high-level analysis. For example, while demand for commuting or business trips is largely driven by levels of employment and demand for other journey purposes is generally related to the level of prosperity, both are encompassed in GDP growth.

At a high level, the differential growth between the two corridors appears inconsistent with the population inputs to Sampers. While both corridors are affected by the very high growth of 59% (from 2000 to 2040) in the Stockholm region, demand to Malmö is also driven by the 43% growth for Skåne county while demand to Gothenburg is driven by the 28% growth for Västra Götaland county.

4.4 Service level

The other influencing factor for demand projections will be the level of service offered. While we understand that no major investment has been assumed between the 2017 base year and the 2040 no HSR scenario, the 2040 no HSR scenario assumes a moderate increase in daily train numbers.

Table 4.7: Number of daily Train Pairs, 2017 and 2040 (direct trains only)

	2017 Base	2040 No HSR	Increase (%)
Stockholm-Gothenburg[6]	27	30	11%
Stockholm-Malmö	19	21	11%

Source: Jacobs analysis of Trafikverket data

This shows similar levels of increase in the train service in the two corridors which is consistent with the similar growth rates in demand. Road congestion and public transport crowding levels will also affect the level of service offered by different modes and both will increase from the 2017 base year to 2040. We have not seen any data on this which would allow an assessment of the relative influence of these two factors.

4.5 Journey time

A consequence of the higher service levels assumed in the 2040 no HSR scenario is that timetabling becomes more constrained and in the absence of new capacity, the journey times increase significantly. In addition, we understand that the X2000 rolling stock will be life-expired by 2040 and will be replaced by conventional trains in the absence of the investment in new lines. Table 4.7 shows the change in rail journey time from 2017 to 2030 that has been assumed in the demand modelling.

Table 4.8: Rail Journey Time

Best Rail Journey Time	2017 Base	2040 No HSR	Change
Stockholm-Gothenburg	3h 00mins	3h 20mins	+11%
Stockholm-Malmö	4h 15mins	4h 41mins	+10%

Source: Trafikverket

We assume that these journey times have been derived by Trafikverket based on robust operational analysis and we have not reviewed this as part of the current scope of demand review. We also assume that these increased journey times are required in part to maintain current levels of punctuality and reliability and that these will not deteriorate further as a result of the more intense train service level.

4.6 High level observations

With the modelling inputs we have been able to examine, the forecast growth in demand for the Stockholm-Gothenburg and Stockholm-Malmö corridors appears realistic. However, it is noted that these inputs include some very aggressive population growth projections, in particular for Stockholm and Skåne counties.

Considering the growth by mode, the low growth in demand for air travel is in line with recent trends. Car demand is predicted to grow more strongly than rail demand in both corridors. We note that this is not in line with recent trends where demand for rail travel has grown more strongly than demand for car travel. However, this may in part have been driven by the rail investment made since the start of the century and similar levels of investment are not envisaged between now and 2040 in the absence of the High-Speed rail project. In fact, it is assumed that rail journey times will deteriorate significantly between 2017 and 2040 as a result of increased train service levels against the background of increasingly constrained network capacity.

[6] Direct route only

5. Projected Future Demand with New Lines (Sampers)

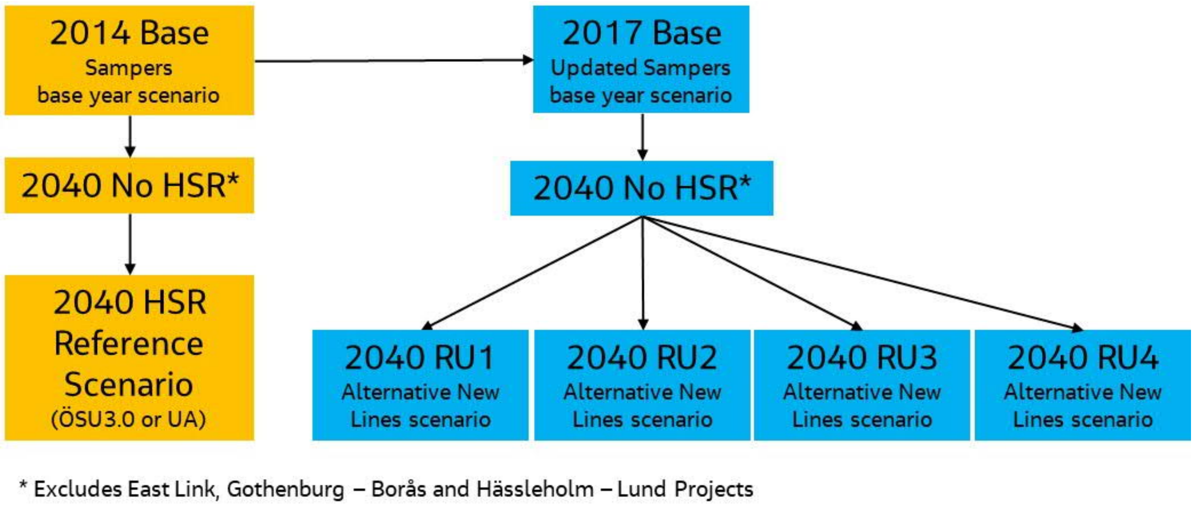
5.1 Scenarios

Forecasts have been provided for four scenarios. An original 2040 New Lines scenario was produced using the 2014-based version of Sampers. This scenario has been referred to as “ÖSU3.0” or “UA” in different documents. To avoid confusion, we will refer to this as the HSR Reference Scenario.

A further four scenarios have been run using the updated 2017-based version of Sampers. These differ in terms of alignment, service level, stopping pattern and journey time and have been referred to as “RU1” to “RU4”.

The relationship of these scenarios to their respective base years and to each other is illustrated in Figure 5.1.

Figure 5.1: Modelled Scenarios



In terms of alignment, the HSR Reference Scenario provides town-centre stations at all intermediate stops with the exception of Värnamo. By contrast:

- RU1 and RU2 have external stations at Norrköping, Linköping, Jönköping, Värnamo and Borås;
- RU3 additionally has an external station at Hässleholm; and
- RU4 has external stations only at Norrköping, Värnamo and Borås.

The key characteristics of these scenarios in terms of service level and journey time are summarised in Figure 5.2.

Figure 5.2: Key Characteristics of Modelled Scenarios

Scenario	Trains per day: Stockholm-Gothenburg	Trains per day: Stockholm-Malmö	Trains per day: Stockholm-Copenhagen	Best Journey time: Stockholm-Gothenburg	Best Journey time: Stockholm-Malmö	Best Journey time: Stockholm-Copenhagen
HSR Reference Scenario	32	30	20	2h 6m	2h 30m	3h 6m
RU1	36 ▲	32 ▲	19 ▼	2h 1m ▼	2h 25m ▼	3h 1m ▼
RU2	40 ▲	38 ▲	19 ▼	1h 56m ▼	2h 22m ▼	2h 58m ▼
RU3	40 ▲	38 ▲	19 ▼	1h 54m ▼	2h 20m ▼	2h 56m ▼
RU4	40 ▲	38 ▲	19 ▼	1h 59m ▼	2h 26m ▼	3h 2m ▼

2040 assumptions

5.2 Rebasing of the 2040 HSR Reference Scenario

As illustrated above, the original HSR Reference Scenario used a different version of the model with a different base year and a different 2040 No HSR forecast. The numbers for this scenario are therefore not strictly comparable with those for the RU1 to RU4 scenarios.

While it would be desirable to re-run the HSR Reference Scenario on the updated version of the model, this has not been done in the time available. To enable a like-for-like comparison, we have therefore used a factoring method to indicatively re-base the HSR Reference Scenario and all subsequent analysis in this report uses this re-based version. Figure 5.3 and Figure 5.4 illustrate the effect of this re-basing on the two corridors.

Figure 5.3: Re-basing of the HSR Reference Scenario, Stockholm-Gothenburg

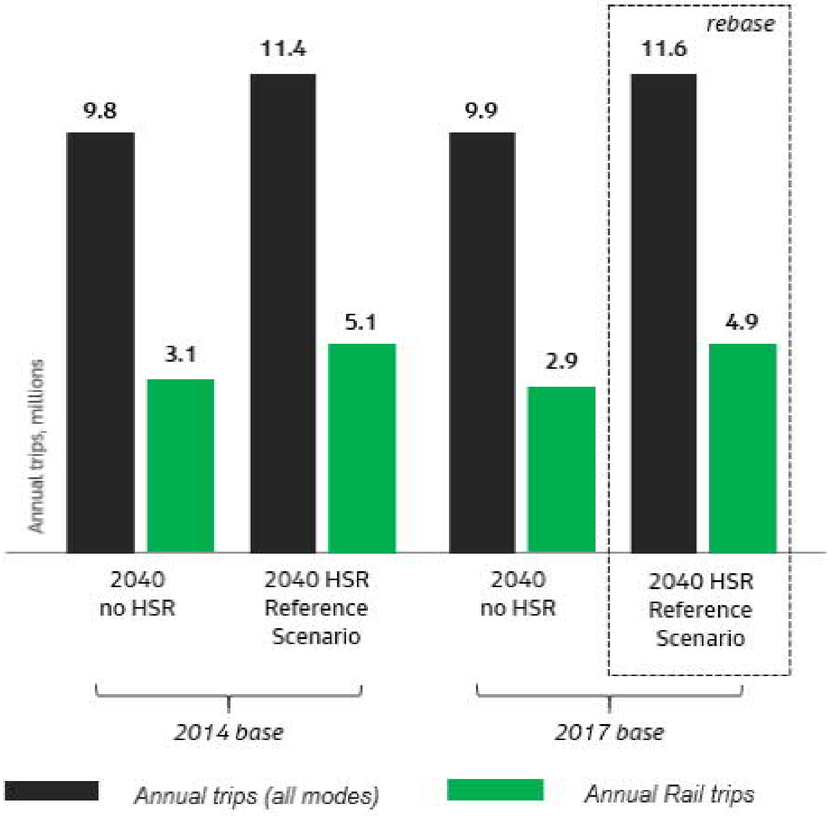
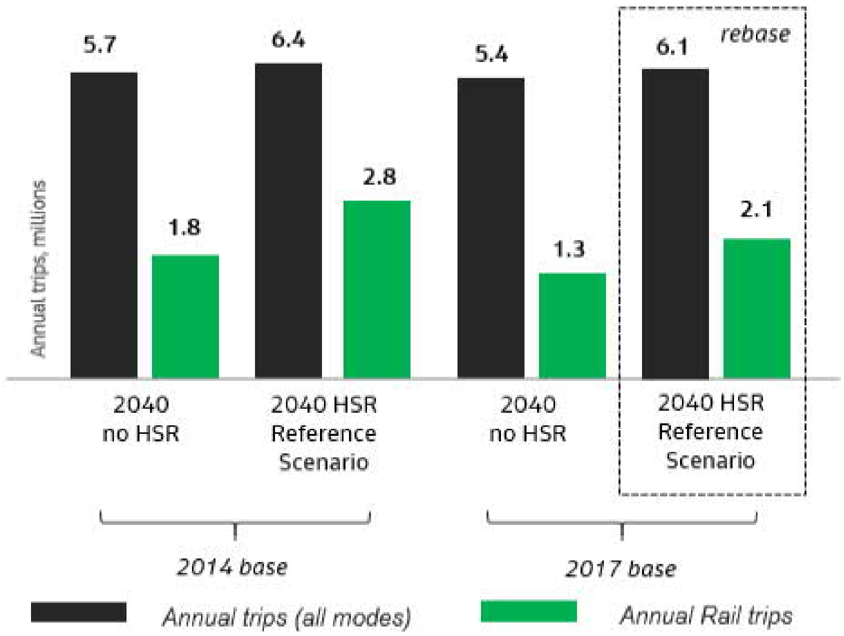


Figure 5.4: Re-basing of the HSR Reference Scenario, Stockholm-Malmö



5.3 2040 forecasts

Table 5.1 and Table 5.2 show the forecast patronage by mode (annual passengers) in 2040 with the proposed High-Speed Rail scheme together with the percentage change in demand from the No HSR scenario.

Table 5.1: Forecast (thousands) Passengers with New Lines in 2040, Stockholm-Gothenburg/Borås

Sampers Forecast	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Car	5,230	5,089	5,030	5,010	5,010	5,010
Bus	410	396	390	390	390	390
Air	1,350	1,251	1,210	1,200	1,200	1,200
Train	2,930	4,868	4,870	5,130	5,190	5,060
Total	9,920	11,604	11,500	11,730	11,790	11,660
% change from no-HSR scenario						
Car	-	-3%	-4%	-4%	-4%	-4%
Bus	-	-3%	-5%	-5%	-5%	-5%
Air	-	-7%	-10%	-11%	-11%	-11%
Train	-	66%	66%	75%	77%	73%
Total	-	17%	16%	18%	19%	18%

Source: Jacobs analysis of Sampers outputs

Table 5.2: Forecast (thousands) Passengers with New Lines in 2040, Stockholm-Malmö/Lund

Sampers Forecast	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU3
Car	2,340	2,293	2,260	2,250	2,260	2,260
Bus	290	290	280	280	280	280
Air	1,460	1,393	1,280	1,270	1,270	1,270
Train	1,270	2,091	2,280	2,410	2,420	2,360
Total	5,360	6,067	6,100	6,210	6,230	6,170
% change from no-HSR scenario						
Car	-	-2%	-3%	-4%	-3%	-3%
Bus	-	0%	-3%	-3%	-3%	-3%
Air	-	-5%	-12%	-13%	-13%	-13%
Train	-	65%	80%	90%	91%	86%
Total	-	13%	14%	16%	16%	15%

Source: Jacobs analysis of Sampers outputs

On the Stockholm to Gothenburg corridor, total patronage by all modes is forecast to be between 17% and 19% higher with High-Speed Rail depending on scenario. Rail (including High-Speed Rail) is forecast to increase by between 66% and 77%. The new trips are largely generated rather than abstracted demand. Air suffers the largest proportional fall in traffic, but in absolute terms, car usage drops by a greater amount.

On the Stockholm to Malmö corridor, total patronage by all modes is forecast to be between 13% and 16% higher with High-Speed Rail, with all types of rail seeing demand increases between 62% and 91%. In this instance, air suffers the greatest proportional and absolute loss in traffic as a result of abstraction to High-Speed Rail – with up to 200,000 fewer trips being made, a decrease of up to 13%. Use of car and bus drops by up to around 4%.

As the number of new trips generated is entirely due to the introduction of High-Speed rail, it is appropriate to calculate what percentage increase they represent over pre-existing rail demand. The number of new trips for Stockholm-Gothenburg/Borås corridor ranges between 1.7 and 1.9m, representing an increase in rail demand of between 54% and 64%. For Stockholm-Malmö/Lund, the increase ranges between 0.7m and 0.9m or between 56% and 69%.

5.4 Journey time elasticity

Sampers is a discrete choice model, not an elasticity-based model. However, from the Sampers forecasts we can calculate the implied elasticities of the model's response. This simplistic elasticity analysis relates this growth to the improvements in journey time achieved by High-Speed rail in the two corridors. Table 5.3 and Table 5.4 shows how the demand change with the scheme in place relates to the change in rail journey time for the two corridors.

Table 5.3: Rail Journey Time and Demand Changes, Stockholm-Gothenburg/Borås

	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Best Rail Journey Time	3h 20mins	2h 06mins	2h 01mins	1h 56mins	1h 54mins	1h 59mins
% change from No HSR	-	-37%	-40%	-42%	-43%	-41%
% change in Rail Demand	-	66%	66%	75%	77%	73%
Implied elasticity	-	-1.8	-1.7	-1.8	-1.8	-1.8

Source: Jacobs analysis

Table 5.4: Rail Journey Time and Demand Changes, Stockholm-Malmö/Lund

	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Best Rail Journey Time	4h 41mins	2h 30mins	2h 25mins	2h 22mins	2h 20mins	2h 26mins
% change from No HSR	-	-47%	-48%	-49%	-50%	-48%
% change in Rail Demand	-	65%	80%	90%	91%	86%
Implied elasticity	-	-1.4	-1.6	-1.8	-1.8	-1.8

Source: Jacobs analysis

This provides journey time elasticity values of between -1.7 and -1.8 for Stockholm-Gothenburg and between -1.4 and -1.8 for Stockholm-Malmö.

Similar values are found in literature for some new High-Speed rail lines. For example, an Italian study[7] found overall journey time elasticities following the introduction of High-Speed rail to range from around -0.7 to -1.1 but quotes higher values for some specific corridors:

- -2.5 for Bologna – Florence; and
- -1.3 for Milan – Naples.

A study by KTH[8] quotes the following journey time elasticities:

- -1.6 for Paris-Lyon phase 1;
- -1.1 for Paris-Lyon phase 2;
- -1.3 for Madrid-Barcelona; and
- -1.1 for Madrid-Seville.

Such comparisons always need to be viewed with caution as it is hard to establish what exactly was measured and how comparable they are. It is also very simplistic to consider journey time only. However, they indicate that forecasts for both corridors are on the high side but not out of scale with international experience.

5.5 Other factors affecting the forecast

In addition to journey time, other factors affecting demand will be fare, frequency and reliability of the service. We understand from Trafikverket that fare levels for the High-Speed lines have been assumed to be unchanged from existing rail fares.

With regard to frequency, Table 5.5 shows the change in the total number of daily train pairs assumed int the forecast. In the New Lines scenarios, this includes High-Speed trains only. In the case of the 2040 HSR Reference Scenario, there will also be 21[9] train pairs on the existing lines between Stockholm and Gothenburg and 4 between Stockholm and Malmö.

Table 5.5: Number of daily Train Pairs, 2040 (direct Trains only)

	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Stockholm-Gothenburg	30	32	36	40	40	40
% change from no HSR	-	7%	20%	33%	33%	33%
Stockholm-Malmö	21	30	32	38	38	38
% change from no HSR	-	43%	52%	81%	81%	81%

Source: Jacobs analysis of Trafikverket data

Of the trains between Stockholm and Malmö, 20 are expected to continue to Copenhagen in the 2040 HSR Reference Scenario, 19 in the RU1 to RU4 scenarios.

The larger increase in the Stockholm to Malmö corridor provides some explanation for the larger percentage increase in rail demand on this route.

Another factor that is often considered to be a driver of growth with the introduction of High-Speed rail is the improvement in reliability and punctuality, both of which have been historically poor on the

[7] Cacetta, E and Coppola, P (undated): High-Speed Rail Demand: Empirical and Modelling Evidence from Italy
[8] Forecasting Demand for High-Speed Rail, Maria Börjesson – KTH, Centre for Transport Studies Stockholm Working Paper 2012:12
[9] Including 14 train pairs on the longer route via Örebro

Swedish rail network. Table 5.6 shows punctuality for long distance, regional trains and freight trains in southern Sweden from 2008 to 2019. A train is defined as punctual in Sweden if it reaches its final destination within 5.9 minutes of the schedule.

Table 5.6: Train Punctuality in Southern Sweden

	2017	2018	2019	Average 2008-2019	Average 2017-2019
Stockholm - Malmö/Copenhagen	65.8%	68.5%	75.3%	67.3%	69.8%
Stockholm - Gothenburg	74.3%	65.2%	78.2%	71.7%	72.6%
Stockholm - Karlstad/Oslo	80.5%	68.1%	72.9%	72.7%	73.9%
Freight Trains	80.8%	73.2%	77.9%	75.5%	77.3%
Gothenburg - Malmö	84.9%	82.2%	85.8%	84.9%	84.3%
Gothenburg - Oslo	91.7%	85.7%	90.7%	81.8%	89.4%
Gothenburg regional trains	93.6%	90.9%	93.9%	92.8%	92.8%
Malmö regional trains	93.8%	92.1%	94.3%	88.4%	93.4%
Stockholm regional trains	92.6%	92.1%	95.9%	93.5%	93.5%
Linköping/Norrköping regional trains	97.4%	96.7%	96.7%	88.8%	96.9%

Source: Trafikverket

In addition, according to information from Trafikverket, around 3% of long-distance passenger trains on the West and South main lines for the years 2017-2019 were cancelled 24 hours before departure.

The expectation is that the availability of additional capacity with the construction of the new lines will not only ensure that the High-Speed rail services achieve high reliability but also that existing services become more reliable. However, we understand that reliability and punctuality are not reflected in the Sampers forecasting model so this would present an upside on the current forecasts.

5.6 New Lines market share

The available data does not allow us to estimate the High-Speed rail market share directly but we can consider the market share for rail and we can assume that for end-to-end travel from Stockholm to Gothenburg and Malmö, the majority of rail demand will be on the High-Speed lines once they are in place. These are shown in Table 5.7 and Table 5.8 respectively for the two corridors.

Table 5.7: Modal Shares following New Lines Project in 2040, Stockholm-Gothenburg/Borås

	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Car	53%	44%	44%	43%	42%	43%
Bus	4%	3%	3%	3%	3%	3%
Air	14%	11%	11%	10%	10%	10%
Train	30%	42%	42%	44%	44%	43%
Total	100%	100%	100%	100%	100%	100%

Source: Jacobs analysis of Sampers outputs

Table 5.8: Modal Shares following New Lines Project in 2040, Stockholm-Malmö/Lund

	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Car	44%	38%	37%	36%	36%	37%
Bus	5%	5%	5%	5%	4%	5%
Air	27%	23%	21%	20%	20%	21%
Train	24%	34%	37%	39%	39%	38%
Total	100%	100%	100%	100%	100%	100%

Source: Jacobs analysis of Sampers outputs

This shows that with the High-Speed lines in place, rail obtains a market share of between 42% and 44% on the Stockholm-Gothenburg route and between 34% and 38% on the Stockholm-Malmö route.

While the proportion of car demand for long distance routes is very difficult to compare with international evidence, the relationship between rail journey time and market share with regard to air is well publicised. A number of diversion graphs are available in the literature that show the proportion of demand attracted to rail and air respectively depending on the rail journey time. One example is reproduced in Figure 5.6.

Figure 5.5: Rail/Air Market Share as a Function of Rail Journey Time

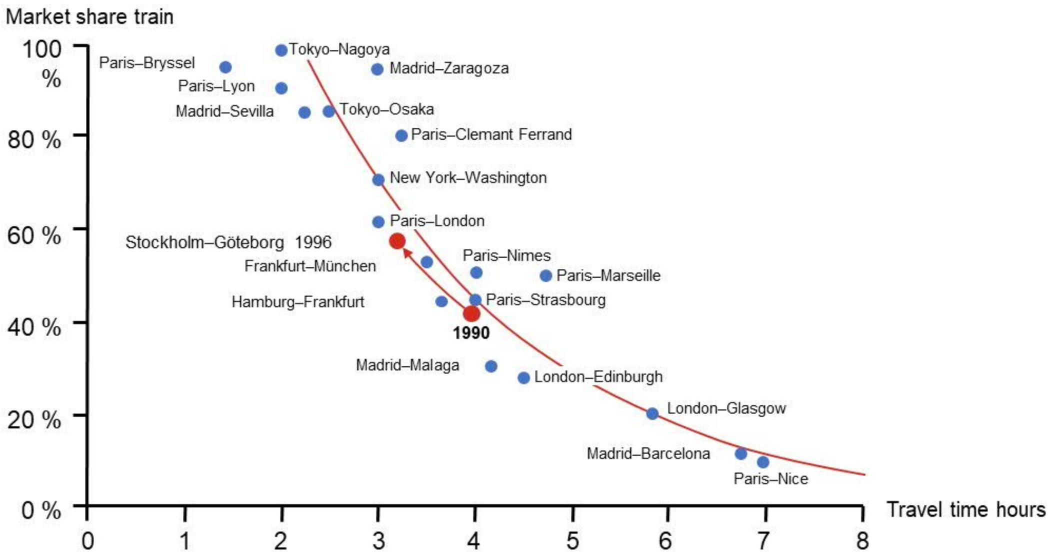


Figure 5.5 shows that rail captures almost the entire market at journey times below about 2 hours.

Once the journey time by rail exceeds the journey time by air by 1 to 2 hours, or the rail journey time increases to around 3 hours, the market share drops to about 50% and decreases rapidly thereafter. With rail journey times of just over 2 hours for the Stockholm-Gothenburg route and 2 ½ hours for the Stockholm-Malmö route, we can estimate the train excess time over air to be around 1 hour for the former and 1 ½ hours for the latter. On that basis, Figure 5.5 suggests that rail should capture around 75% of the combined rail/air market for Stockholm-Gothenburg and around 60% for Stockholm-Malmö. Looking at the absolute journey times, Figure 5.6 suggest that rail should capture around 90% of the combined rail/air market for Stockholm-Gothenburg and around 80% for Stockholm-Malmö.

Analysing the numbers from Table 5.1 and Table 5.2 in those terms gives the shares shown in Table 5.9.

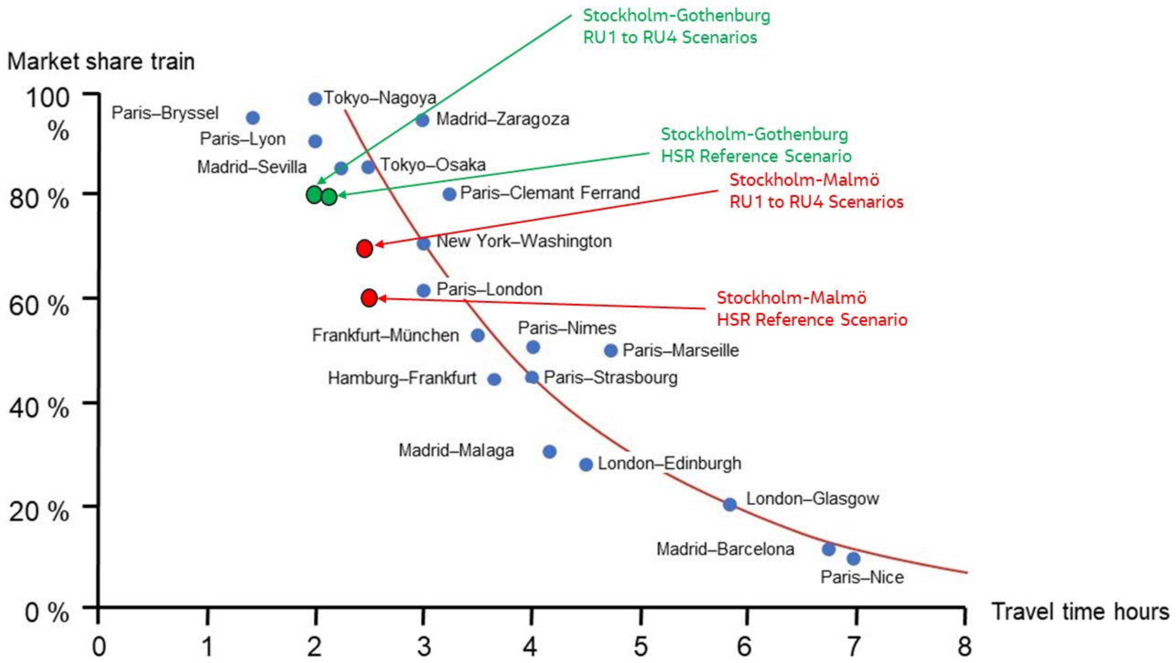
Table 5.9: 2040 New Lines Forecast for Air/Rail Shares

	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Stockholm-Gothenburg Rail as % of Rail+Air	68%	80%	80%	81%	81%	81%
Stockholm-Gothenburg Air as % of Rail+Air	32%	20%	20%	19%	19%	19%
Stockholm-Malmö Rail as % of Rail+Air	47%	60%	64%	65%	66%	65%
Stockholm-Malmö Air as % of Rail+Air	53%	40%	36%	35%	34%	35%

Source: Jacobs analysis of Sampers outputs

When plotted on the curve from Figure 5.6, we can see how these proportions compare with international evidence as illustrated in Figure 5.7.

Figure 5.6: Rail/Air Market Share for New Lines in international Comparison

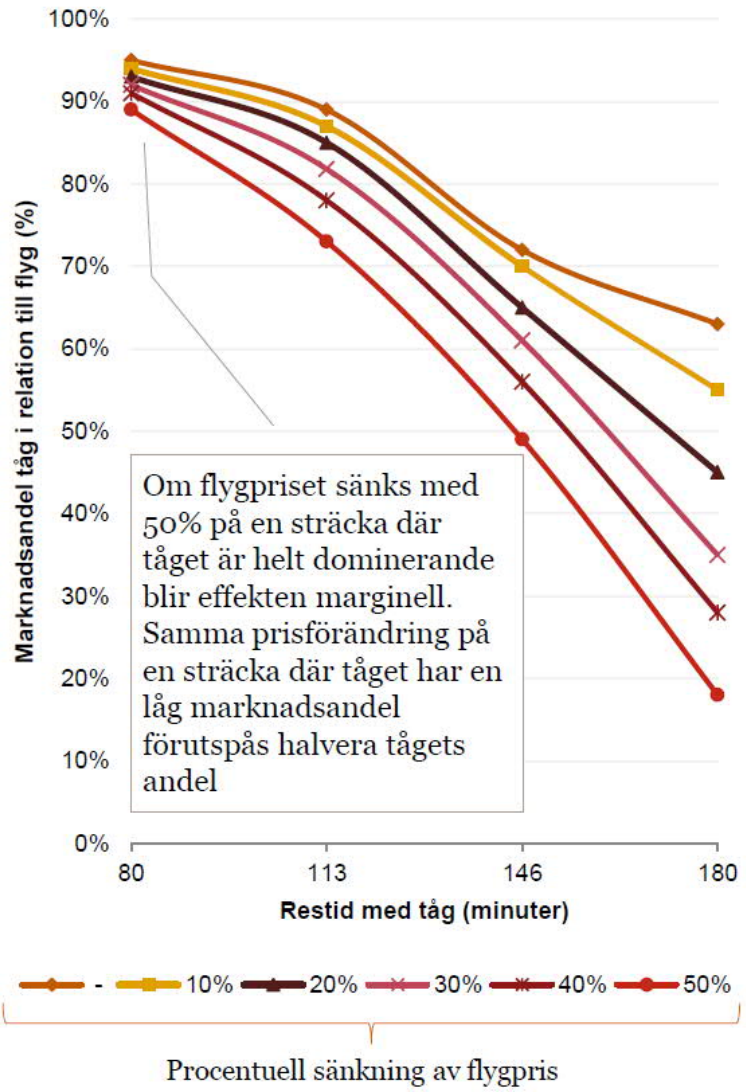


This suggests that the forecast rail shares on both routes lie below those that might be expected from international comparison. We also note that the rail vs rail/air share that is achieved is not as a result of abstraction from the air market which we would regard as very low (Table 5.7 and Table 5.8) – and much lower than in the PwC forecasts that are discussed in the next chapter. However, we also note that levels of air demand have grown at a much lower rate from 2017 to 2040 than demand for other modes (Table 4.1 and Table 4.2) and the share of air demand as a proportion of the total market is low in both the no HSR and the with HSR forecasts, with car dominating the market without New Lines and attracting a similar share to rail in the with HSR scenarios.

Looking at the historical trend of aviation and rail demand as described in chapter 3, we expect that much of the demand that can easily transfer from air to rail has already done so in the last 20 years. What remains is the harder-to-reach air demand, including longer distance interlining passengers with an additional travel leg at either end of their journey via Arlanda or Kastrup. As their desired destination is the airport rather than the cities of Stockholm or Copenhagen, air has an additional journey time advantage over the train. In addition, many of these travellers will be travelling using airline transfer tickets which make using the train alternative for one of their journey legs financially unattractive. Other harder-to-reach air demand may include travellers from the north of Sweden who have to travel past Arlanda if they want to reach Stockholms Centralstation for an onward rail journey to Gothenburg or Malmö.

It is also instructive in this context to review evidence presented by the PwC forecast on the impact of price and journey time respectively on the mode of transport. The relationship between journey time, price and mode share is illustrated in Figure 5.8. This shows the market share of train in relation to the total train/air demand (%) as a function of rail journey time and price.

Figure 5.7: Train Market Share in relation to Price Change



Source: PwC Forecast (4 September 2015): Sweden Negotiation – Commercial Qualifications for High-Speed Trains in Sweden

This confirms the conclusions above, that the train becomes increasingly attractive at journey times below 3 hours, and becomes dominant at around 2 ½ hours, capturing a market share of between 70% and 85%. Even if the air fare is reduced by 50%, train remains the dominant mode, with the mode share dropping from around 70 to 50% according to Figure 5.8. However, the impact of price is much more significant at longer train journey times, with Figure 5.8 indicating that, at a 3 hour rail journey time, the rail share may drop substantially (from around 65% to 20%) if air fares are reduced significantly.

The competitive response of airlines to the introduction of new High-Speed rail lines in Sweden therefore needs to be considered one of the potential risks and uncertainties attached to the forecasts of future demand for High-Speed rail. However, if rail journey times of 2 ½ hours or less can be achieved, and the rail fare strategy is carefully considered, it will be commercially difficult for airlines to compete effectively on price.

5.7 High level observations

The material we have been able to examine suggests that the overall growth in demand once the High-Speed lines are in place is high when compared with the level of journey time improvement. However, such high growth is not unprecedented in international comparison, and the simplistic nature of a journey time elasticity calculation ignores other factors such as frequency and reliability improvements.

By contrast to the generated demand, we would regard the abstraction from other modes as modest and forecasts for the Stockholm-Copenhagen route do not take account of the potential to abstract demand from other modes, in particular air.

6. Comparison Forecast

6.1 PwC Forecasts

6.1.1 Background

In 2015, Trafikverket commissioned PwC to review the commercial conditions that affect demand for train travel in Sweden in the context of new trunk lines between Stockholm and Malmö and Stockholm and Gothenburg. The report was focused on the financial and commercial case for the project and included issues such as yield requirements, operating costs and costs for rolling stock. However, it was also concerned with customer demand, willingness to pay and preferences and has produced a set of forecasts for future High-Speed rail travel demand with a focus on a 2039 forecast year.

The underlying network assumptions made in PwC's forecasts are not identical to those currently used by Trafikverket but are quite similar as shown in Table 6.1.

Table 6.1: Journey Times and Service Patterns in the HSR Reference Scenario and PwC Forecasts

Route	Forecast	Direct Service	Stopping Service	Stops
Stockholm-Gothenburg	HSR Reference Scenario	2h 6min	2h 30min	Norrköping Linköping Jönköping Borås
	PwC Forecast	2h 0min	2h 30min	Norrköping Linköping Jönköping Undefined
Stockholm-Malmö	HSR Reference Scenario	2h 30min	3h 0min	Norrköping Linköping Jönköping Hässleholm Lund
	PwC Forecast	2h 30min	3h 0min	Norrköping Linköping Jönköping Lund

Source: Trafikverket

The shorter journey time for the Stockholm-Gothenburg non-stop trains in the PwC forecast is driven by the assumption of a speed of 320 km/h on Eastlink. The assumed daily service level is similar between the two forecasts for the Stockholm-Gothenburg corridor but Trafikverket's 2040 HSR Reference Scenario assumes a higher service level on the Stockholm-Malmö route as shown in Table 6.2.

Table 6.2: Number of daily Train Pairs (direct High-Speed Line Trains only)

	2040 HSR Reference Scenario	2039 PwC Forecast
Stockholm-Gothenburg	32	32
Stockholm-Malmö	30	Approx. 25

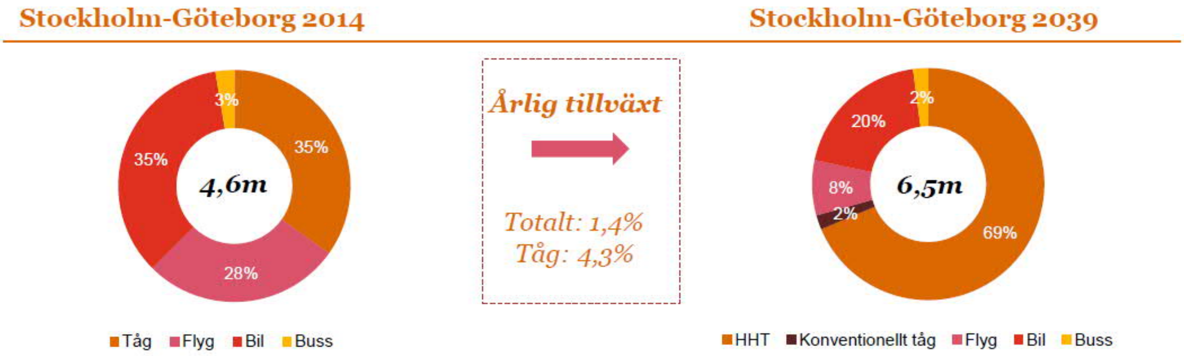
Source: Trafikverket

In addition, there are services for both city pairs using the existing lines as shown in Table 5.5 for the HSR Reference Scenario forecast. What services on existing lines were assumed in the PwC forecast is not known.

6.1.2 End-to-End Demand

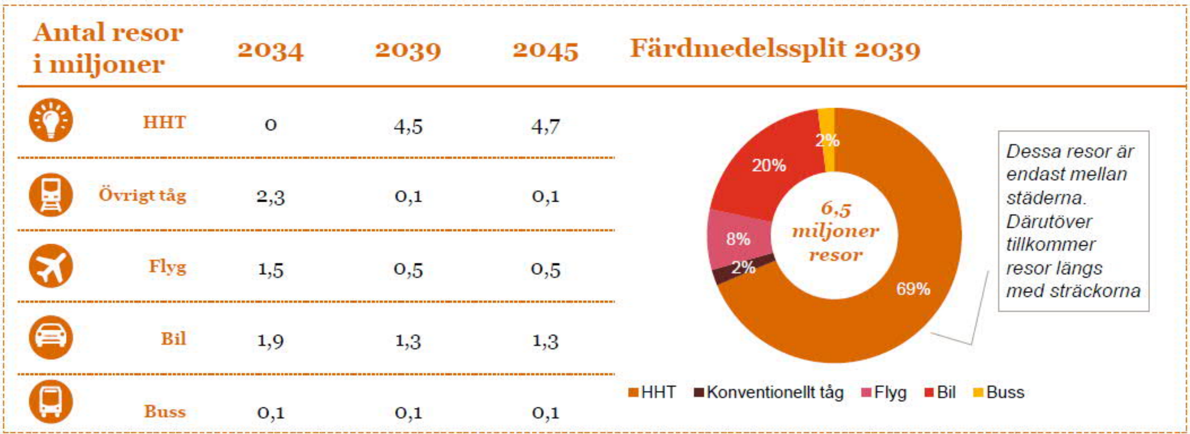
The PwC forecasts for annual end-to-end travellers on the Stockholm-Gothenburg and the Stockholm-Malmö corridor are reproduced in the following. Figure 6.1 and Figure 6.2 show total annual demand by mode and growth from 2014.

Figure 6.1: Stockholm-Gothenburg Annual End to End Travellers Projection



Source: PwC Forecast (4 September 2015): Sweden Negotiation – Commercial Qualifications for High-Speed Trains in Sweden

Figure 6.2: Stockholm-Gothenburg End to End Demand Forecast



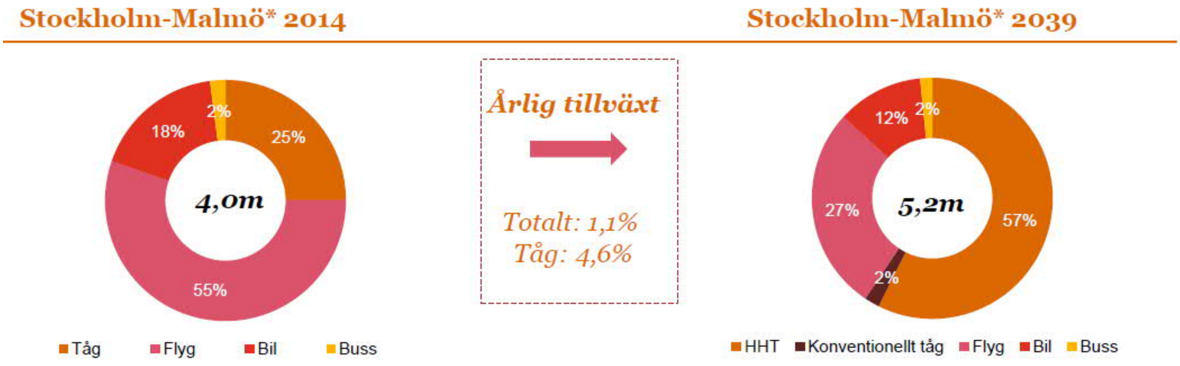
Antal resor i miljoner	2034	2039	2045
HHT	0	4,5	4,7
Övrigt tåg	2,3	0,1	0,1
Flyg	1,5	0,5	0,5
Bil	1,9	1,3	1,3
Buss	0,1	0,1	0,1

Source: PwC Forecast (4 September 2015): Sweden Negotiation – Commercial Qualifications for High-Speed Trains in Sweden

The PwC forecasts show that end-to-end demand is predicted to increase from 4.6m annual trips in 2014 to 5.8m in 2034 prior to the introduction of High-Speed rail. In 2039 with High-Speed rail in place, total demand will have grown to 6.5m with very little further growth to 2045. In 2039, HSR will have a mode share of 69% (4.5m trips). Around half of the High-Speed rail demand will come from other rail, the rest from air, car and new generation of trips.

The same information is presented for the Stockholm-Malmö/Copenhagen corridor in Figure 6.3 and Figure 6.4.

Figure 6.3: Stockholm-Malmö/Copenhagen Annual End to End Travellers Projection

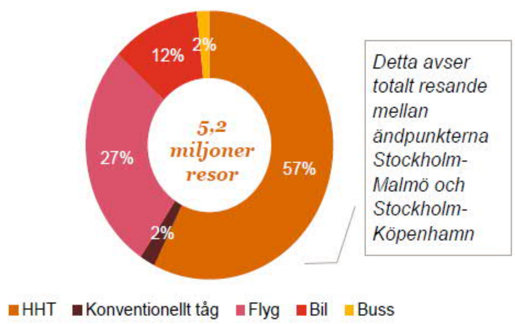


Source: PwC Forecast (4 September 2015): Sweden Negotiation – Commercial Qualifications for High-Speed Trains in Sweden

Figure 6.4: Stockholm-Malmö/Copenhagen End to End Demand Forecast

Antal resor i miljoner	2034	2039	2045
HHT	-	3,0	3,1
Övrigt tåg	1,4	0,1	0,1
Flyg	2,6	1,4	1,4
Bil	0,8	0,6	0,6
Buss	0,1	0,1	0,1

Färdmedelssplit 2039



Source: PwC Forecast (4 September 2015): Sweden Negotiation – Commercial Qualifications for High-Speed Trains in Sweden

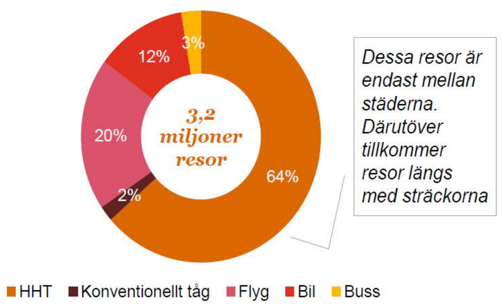
This shows end-to-end demand is predicted to increase from 4.0m annual trips in 2014 to 4.9m in 2034 prior to the introduction of High-Speed rail. In 2039 with High-Speed rail in place, total demand will have grown to 5.2m with very little further growth to 2045. In 2039, HSR will have a mode share of 57% (3.0m trips). As for the Stockholm-Gothenburg corridor, around half of the High-Speed rail demand will come from other rail, the rest from air, car and new generation of trips.

In Figure 6.5 trips to Copenhagen have been excluded from the Stockholm – Malmö totals. No equivalent figure for the growth from 2014 to 2039 is available in the PwC forecast.

Figure 6.5: Stockholm-Malmö End to End Demand Forecast excluding Trips to Copenhagen

Antal resor i miljoner	2034	2039	2045
HHT	-	2,0	2,1
Övrigt tåg	1,0	0,1	0,1
Flyg	1,2	0,6	0,6
Bil	0,6	0,4	0,4
Buss	0,1	0,1	0,1

Färdmedelssplit 2039



Source: PwC Forecast (4 September 2015): Sweden Negotiation – Commercial Qualifications for High-Speed Trains in Sweden

Comparing Figure 6.4 with Figure 6.5 shows that the Copenhagen demand accounts for around 1m annual trips on High-Speed rail and around 0.8m by air but only about 200,000 car trips.

6.1.3 Key base year and future base forecast differences

The PwC forecasts are contrasted with the Sampers-based forecast in the following set of tables[10]. Although the Stockholm-Malmö and Stockholm-Copenhagen markets are not always presented separately in the PwC forecast, we have used our analysis to separate them out in this section. This is based on our interpretation of the available data as follows:

- The PwC forecast 2034 figures without Copenhagen are those provided directly by PwC (see Figure 6.5) and demand for the Copenhagen market is derived by assessing the difference between these and the numbers in Figure 6.4; and
- The “PwC forecast 2014” figures are our estimate based on the assumption that 2014 air demand between Stockholm and Copenhagen is around 1.45m (Figure 3.5) and that demand to Copenhagen for the other modes represents the same proportion as in the 2034 numbers given.

Total demand in the base year and a forecast scenario without High-Speed rail (2040 for Sampers and 2034 for the PwC forecast) is summarised in Table 6.3 to Table 6.5. The 2014 PwC forecast numbers are calculated from the totals and the mode share proportions given in Figure 6.1 and Figure 6.3.

[10] As all the PwC forecast numbers are only provided to the nearest 100,000, these tables contain some rounding errors.

Table 6.3: Passengers (thousands) Stockholm – Gothenburg[11], Sampers and PwC Forecast

	2017 Base	2040 No HSR	PwC 2014	PwC 2034 No HSR
Car	3,310	5,230	1,610	1,900
Bus	280	410	138	100
Air	1,170	1,350	1,288	1,500
Train	1,880	2,930	1,610	2,300
Total	6,640	9,920	4,646	5,800

Source: Sampers and Jacobs interpretation of PwC forecast

Table 6.4: Passengers (thousands) Stockholm – Malmö[12], Sampers and PwC Forecast

	2017 Base	2040 No HSR	PwC 2014	PwC 2034 No HSR
Car	1,370	2,340	540	600
Bus	190	290	80	100
Air	1,280	1,460	750	1,200
Train	780	1,270	714	1,000
Total	3,620	5,360	2,084	2,900

Source: Sampers and Jacobs interpretation of PwC forecast

Table 6.5: Passengers (thousands) Stockholm – Copenhagen, Sampers and PwC Forecast

	2017 Base	2040 No HSR	"PwC 2014"	PwC 2034 No HSR
Car	0	0	180	200
Bus	0	0	0	0
Air	0	0	1,450	1,400
Train	240	330	286	400
Total	240	330	1,916	2,000

Source: Sampers and Jacobs interpretation of PwC forecast

In the Stockholm-Gothenburg corridor, the PwC forecast base year total demand is around 30% lower than the Sampers base year demand, with car demand some 51% and rail demand some 14% lower. Air demand is higher by about 10% in the PwC forecast numbers.

In the Stockholm-Malmö corridor, the PwC forecast base year total demand is around 42% lower than the Sampers base year demand and all modes are lower, ranging from 8% lower for air to 61% lower for car. Between Stockholm and Copenhagen, the numbers are not strictly comparable because Sampers only includes rail demand.

As we have already noted in chapter 2, it is very difficult to establish how comparable base year numbers from different sources are. The use of the "labour market region" definition in the case of Sampers may be one important source of the differences we observe. Nonetheless it is worth noting

[11] In the case of Sampers, this is the Gothenburg and Borås labour market region. For the PwC forecast numbers the area definition is not known

[12] In the case of Sampers, this is the Malmö & Lund labour market region. For the PwC forecast numbers the area definition is not known

that the starting point for forecasting is significantly lower for the PwC forecasts compared to those based on Sampers for the Stockholm-Gothenburg and Stockholm-Malmö markets but significantly higher for the Stockholm-Copenhagen market.

Following this base year comparison, we now turn our attention to the forecast future scenario in the absence of the High-Speed rail scheme. As shown in Table 6.3 and Table 6.4, forecast demand is also lower in the PwC forecast case, by some 41% for the Stockholm-Gothenburg corridor and 46% for the Stockholm-Malmö route, though the PwC forecast is for a 2034 forecast year compared to 2040 for Sampers. In Table 6.6 to Table 6.8 we compare the growth rates by mode between the two forecasts for the three corridors.

Table 6.6: Passenger Growth Stockholm – Gothenburg[13], Sampers and PwC Forecast

	Sampers Growth 2017-2040	Average annual growth	PwC Growth 2014-2034	Average annual growth
Car	58.0%	2.0%	18.0%	0.6%
Bus	46.4%	1.7%	-27.5%	-1.2%
Air	15.4%	0.6%	16.5%	0.6%
Train	55.9%	1.9%	42.9%	1.4%
Total	49.2%	1.8%	24.8%	0.9%

Source: Jacobs analysis

Table 6.7: Passenger Growth Stockholm – Malmö[14], Sampers and PwC Forecast

	Sampers Growth 2017-2040	Average annual growth	PwC Growth 2014-2034	Average annual growth
Car	70.8%	2.4%	11.1%	0.4%
Bus	52.6%	1.9%	25.0%	0.9%
Air	14.1%	0.6%	60.0%	1.8%
Train	62.8%	2.1%	40.0%	1.3%
Total	48.1%	1.7%	39.1%	1.3%

Source: Jacobs analysis

Table 6.8: Passenger Growth Stockholm – Copenhagen, Sampers and PwC Forecast

	Sampers Growth 2017-2040	Average annual growth	PwC Growth 2014-2034	Average annual growth
Car	n/a	n/a	11.1%	0.4%
Bus	n/a	n/a	n/a	n/a
Air	n/a	n/a	-3.4%	-0.1%
Train	37.5%	1.4%	40.0%	1.3%
Total	37.5%	1.4%	4.4%	0.2%

Source: Jacobs analysis

[13] In the case of Sampers, this is the Gothenburg and Borås labour market region. For the PwC forecast numbers the area definition is not known

[14] In the case of Sampers, this is the Malmö & Lund labour market region. For the PwC forecast numbers the area definition is not known

This shows that overall growth is significantly lower in the PwC forecast case compared with the Sampers forecasts, amounting to 25%-39% compared with 48%-49% for Sampers for the main corridors to Gothenburg and Malmö. Growth in the corridor to Copenhagen is just 4% in the PwC forecasts. This is also reflected in the average annual growth rate which is more directly comparable as it takes account of the shorter forecasting period for the PwC forecast numbers. When analysed by mode, both sets of forecasts predict very modest growth for air and significant growth for rail in both the Stockholm-Gothenburg and Stockholm-Malmö corridor. For Stockholm-Malmö, the PwC forecast also predicts significant air growth. Where the two sets of forecasts differ most is in the predicted growth for car demand which sees the largest percentage increase of any mode in the Sampers forecasts but only moderate growth in the PwC forecast.

Table 6.9 to Table 6.11summarise the mode shares for base year and forecast scenario for the three corridors.

Table 6.9: Mode Shares Stockholm – Gothenburg[15], Sampers and PwC Forecast

	Sampers 2017 Mode Shares	2040 No HSR Mode Shares	PwC 2014 Mode Shares	PwC 2034 no HSR Mode Shares
Car	50%	53%	35%	33%
Bus	4%	4%	3%	2%
Air	18%	14%	28%	26%
Train	28%	30%	35%	40%
Total	100%	100%	100%	100%

Source: Jacobs analysis

Table 6.10: Mode Shares Stockholm – Malmö[16], Sampers and PwC Forecast

	Sampers 2017 Mode Shares	2040 No HSR Mode Shares	PwC 2014 Mode Shares	PwC 2034 no HSR Mode Shares
Car	38%	44%	26%	21%
Bus	5%	5%	4%	3%
Air	35%	27%	36%	41%
Train	22%	24%	34%	34%
Total	100%	100%	100%	100%

Source: Jacobs analysis

[15] In the case of Sampers, this is the Gothenburg and Borås labour market region. For the PwC forecast numbers the area definition is not known

[16] In the case of Sampers, this is the Malmö & Lund labour market region. For the PwC forecast numbers the area definition is not known

Table 6.11: Mode Shares Stockholm – Copenhagen, Sampers and PwC Forecast

	Sampers 2017 Mode Shares	2040 No HSR Mode Shares	PwC 2014 Mode Shares	PwC 2034 no HSR Mode Shares
Car	Cannot be meaningfully calculated because Sampers only contains rail demand to Copenhagen		9%	10%
Bus			0%	0%
Air			76%	70%
Train			15%	20%
Total			100%	100%

Source: Jacobs analysis

In the Stockholm-Gothenburg corridor, Sampers predicts an increase in mode share for rail and car travel at the expense of air. The PwC forecast sees some increases in the rail share at the expense of both car and air. The PwC forecast shows a higher rail share in both the base and the forecast year than the Sampers projection.

In the Stockholm-Malmö corridor, Sampers also forecasts a decline in the air share with both car and train gaining shares. The PwC forecast projects an increase in the air share at the expense of car. For the Stockholm-Copenhagen market, the PwC forecast predicts a small increase in the rail share at the expense of air.

6.1.4 Key differences in High-Speed rail forecasts

The two forecasts with the High-Speed rail project in place are contrasted in Table 6.12 to Table 6.14.

Table 6.12: Sampers and PwC HSR Forecasts (thousands), Stockholm-Gothenburg/Borås, 2039/40

	2040 No HSR	2040 HSR Reference Scenario (re-based)	PwC 2034 no HSR	PwC 2039 with HSR
Car	5,230	5,089	1,900	1,300
Bus	410	396	100	100
Air	1,350	1,251	1,500	500
Train	2,930	4,868	2,300	4,600
Total	9,920	11,604	5,800	6,500

Source: Sampers and Jacobs interpretation of PwC forecast

Table 6.13: Sampers and PwC HSR Forecasts (thousands), Stockholm-Malmö/Lund, 2039/40

	2040 No HSR	2040 HSR Reference Scenario (re-based)	PwC 2034 no HSR	PwC 2039 with HSR
Car	2,340	2,293	600	400
Bus	290	290	100	100
Air	1,460	1,393	1,200	600
Train	1,270	2,091	1,000	2,100
Total	5,360	6,067	2,900	3,200

Source: Sampers and Jacobs interpretation of PwC forecast

Table 6.14: Sampers and PwC HSR Forecasts (thousands), Stockholm-Copenhagen, 2039/40

	2040 No HSR	2040 HSR Reference Scenario (re-based)	PwC 2034 no HSR	PwC 2039 with HSR
Car	0	0	200	200
Bus	0	0	0	0
Air	0	0	1,400	800
Train	330	330	400	1,000
Total	330	330	2,000	2,000

Source: Sampers and Jacobs interpretation of PwC forecast

The much lower numbers in both the Swedish corridors in the PwC forecasts are derived from a smaller geographical area than the labour market regions used in the Sampers analysis. However, despite the different base year starting points and significant differences in mode share, the forecasts for High-Speed rail demand are rather similar between Sampers and the PwC forecast in both corridors. For the corridor to Copenhagen, the PwC forecasts are higher by orders of magnitude. Not only do they start from a higher base rail demand, but they are able from other modes which are not represented in Sampers. The resulting mode shares in the forecasts with High-Speed rail in place are summarised in Table 6.15 to Table 6.17.

Table 6.15: Sampers and PwC Forecast Mode Shares, Stockholm-Gothenburg/Borås, 2039/40

	2040 HSR Reference Scenario (re-based)	Market Share (%)	PwC 2039	Market Share (%)
Car	5,089	44%	1,300	20%
Bus	396	3%	100	2%
Air	1,251	11%	500	8%
Train	4,868	42%	4,600	71%
Total	11,604	100%	6,500	100%

Source: Sampers and Jacobs interpretation of PwC forecast

Table 6.16: Sampers and PwC Forecast Mode Shares, Stockholm-Malmö/Lund, 2039/40

	2040 HSR Reference Scenario (re-based)	Market Share (%)	PwC 2039	Market Share (%)
Car	2,293	38%	400	13%
Bus	290	5%	100	3%
Air	1,393	23%	600	19%
Train	2,091	34%	2,100	66%
Total	6,067	100%	3,200	100%

Source: Sampers and Jacobs interpretation of PwC forecast

Table 6.17: Sampers and PwC Forecast Mode Shares, Stockholm-Copenhagen, 2039/40

	2040 HSR Reference Scenario (re-based)	Market Share (%)	PwC 2039	Market Share (%)
Car	Cannot be meaningfully calculated because Sampers only contains rail demand to Copenhagen		200	10%
Bus			0	0%
Air			800	40%
Train			1,000	50%
Total			2,000	100%

Source: Sampers and Jacobs interpretation of PwC forecast

This shows that the PwC forecast predicts that High-Speed rail is able to capture market share much more aggressively than the Sampers forecast. While Sampers suggests that rail will capture only between 34% and 42% of the total market, the PwC forecast predicts 71%, 66% and 50% for the three corridors respectively.

Given the similarities of both forecasts against a background of different base year and future base projections, it is instructive to examine where the High-Speed rail demand has been extracted from in both sets of forecasts. This is summarised in Table 6.18 to Table 6.20.

Table 6.18: Origin of High-Speed Rail Demand, Stockholm-Gothenburg/Borås, 2039/40

	2040 HSR Reference Scenario (re-based)	% of new rail demand	PwC 2039 with HSR	% of new rail demand
From Car	141	3%	600	13%
From Bus	14	0%	0	0%
From Air	99	2%	1,000	22%
From Train	2,930	60%	2,300	50%
Generated Demand	1,684	35%	700	15%
Total	4,868	100%	4,600	100%

Source: Sampers and Jacobs interpretation of PwC forecast

Table 6.19: Origin of High-Speed Rail Demand, Stockholm-Malmö/Lund, 2039/40

	2040 HSR Reference Scenario (re-based)	% of new rail demand	PwC 2039 with HSR	% of new rail demand
From Car	47	2%	200	10%
From Bus	0	0%	0	0%
From Air	67	3%	600	29%
From Train	1,270	61%	1,000	48%
Generated Demand	707	34%	300	14%
Total	2,091	100%	2,100	100%

Source: Sampers and Jacobs interpretation of PwC forecast

Table 6.20: Origin of High-Speed Rail Demand, Stockholm-Copenhagen, 2039/40

	2040 HSR Reference Scenario (re-based)	% of new rail demand	PwC 2039 with HSR	% of new rail demand
From Car	0	0%	600	13%
From Bus	0	0%	0	0%
From Air	0	0%	1,000	22%
From Train	330	100%	2,300	50%
Generated Demand	0	0%	700	15%
Total	330	100%	4,600	100%

Source: Sampers and Jacobs interpretation of PwC forecast

This shows a profound difference in the two sets of predictions. While both agree that the majority of High-Speed rail demand will come from existing rail patronage, the PwC forecast projects a much higher abstraction from air and car than Sampers. By contrast, Sampers predicts a much higher level of generated demand.

In this context it is instructive to examine the air/rail shares in the PwC forecasts compared with those shown for the Sampers forecasts in Table 5.9. The equivalent figures for the PwC forecast are presented in Table 6.21

Table 6.21: 2039 PwC New Lines Forecast (thousands) for Air/Rail Shares

PwC Forecast	Air Demand	Rail Demand	Air Share	Rail Share
Stockholm-Gothenburg	500	4,600	10%	90%
Stockholm-Malmö	600	2,100	22%	78%
Stockholm-Copenhagen	800	1,000	44%	56%

Source: Jacobs interpretation of PwC forecast

This shows a very high capture of the combined market by rail for the Stockholm-Gothenburg route with 90% of demand falling to rail (but still within the range of the international comparison shown in chapter 5). The equivalent figure from Sampers is 80%. In the Stockholm-Malmö corridor, the PwC forecast shows lower market penetration with 78% (Sampers 60%). For the demand to Copenhagen, the PwC forecast projects a rail share of 56% (there is no comparable figure for Sampers available).

6.1.5 High level observations

It is striking that both Sampers and the PwC forecast arrive at very similar forecasts for High-Speed rail demand in both corridors despite some major differences in the background to the forecasts.

Both the base year demand levels and the levels of growth in demand in the absence of the High-Speed rail scheme are substantially lower in the PwC forecast projections. By contrast, the level of abstraction from other modes is much higher in the PwC forecasts, particularly from air. Sampers, on the other hand, predicts a much higher level of generated demand, particularly on the Stockholm-Gothenburg route.

6.2 Trafikverket alternative analysis

6.2.1 Background

In addition to the Sampers-based forecasts, Trafikverket have produced an alternative projection based on a comparison of journey time, frequency and reliability improvements with those experienced elsewhere internationally when High-Speed rail was introduced. In the following we will refer to this as the “TRV analysis”. This uses the same geographical definitions as the Sampers analysis, which makes these projections more comparable with the model outputs than the PwC forecasts.

Undertaking simple and easy-to-follow calculations is a good way of validating results from a complex model. This gives three different sets of forecasts to compare:

- Projections from a complex network-based discrete choice model (Sampers);
- PwC forecasts, based on market analysis, surveys and international experience; and
- TRV analysis, based on comparisons with corridors in France and Italy.

6.2.2 Underlying growth

The TRV analysis has assumed underlying growth from 2019 to 2040 of 30% to 32% (Table 6.22), which is equivalent to 1.3% pa over the 21 year period.

Table 6.22: TRV Analysis Growth from Base Year

	2019		2040		Overall growth	Rail growth
	All demand (millions pa)	Rail Proportion	All demand (millions pa)	Rail Proportion	%	%
Stockholm-Gothenburg	5.7	37%	7.4	38%	30%	32%
Stockholm-Malmö	3.6	28%	4.7	28%	30%	30%
Stockholm-Copenhagen	2.4	12%	3.2	20%	30%	114%

Source: TRV analysis and Jacobs Analysis

For comparison, Sampers shows growth of 49% Stockholm-Gothenburg and 48% Stockholm-Malmö (Table 6.23), equivalent to 1.8% pa (Gothenburg) and 1.7% pa (Malmö) over 23 years.

Table 6.23: Sampers Forecast Growth from Base Year

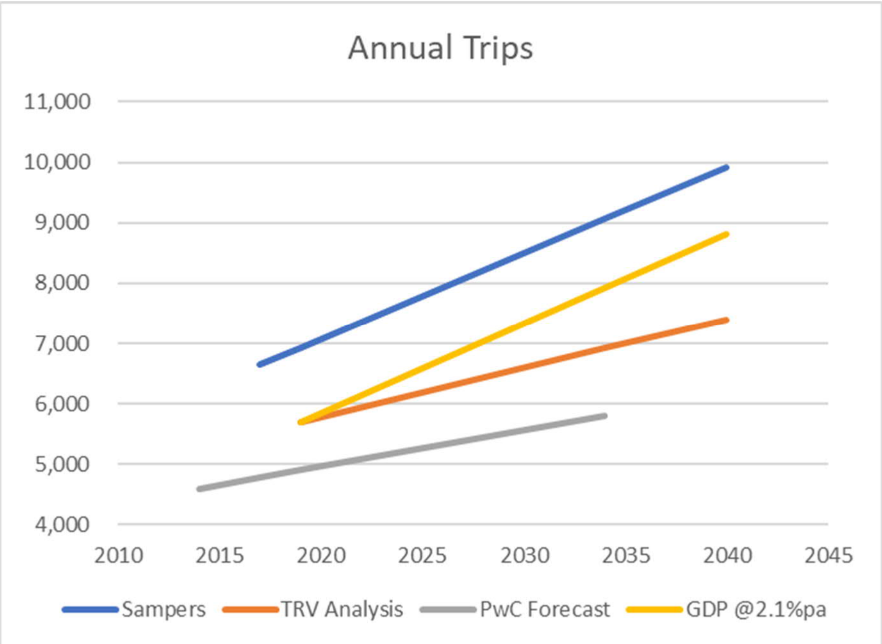
	2017		2040		Overall growth %	Rail growth %
	All demand (millions pa)	Rail Proportion	All demand (millions pa)	Rail Proportion		
Stockholm-Gothenburg	6.6	28%	9.9	30%	49%	56%
Stockholm-Malmö	3.6	22%	5.4	24%	48%	63%
Stockholm-Copenhagen	0.2	100%	0.3	100%	38%	38%

Source: Jacobs Analysis of Sampers outputs

These growth rates may be compared to projected annual GDP growth of 2.1% which would give a 55% growth over 21 years. In addition to the different growth levels, the starting positions are different: 2019 totals are 14% lower than the 2017 Sampers base for both the Gothenburg corridor but similar for the Malmö corridors. The numbers for the Copenhagen corridor are not comparable because Sampers only includes a representation of rail demand.

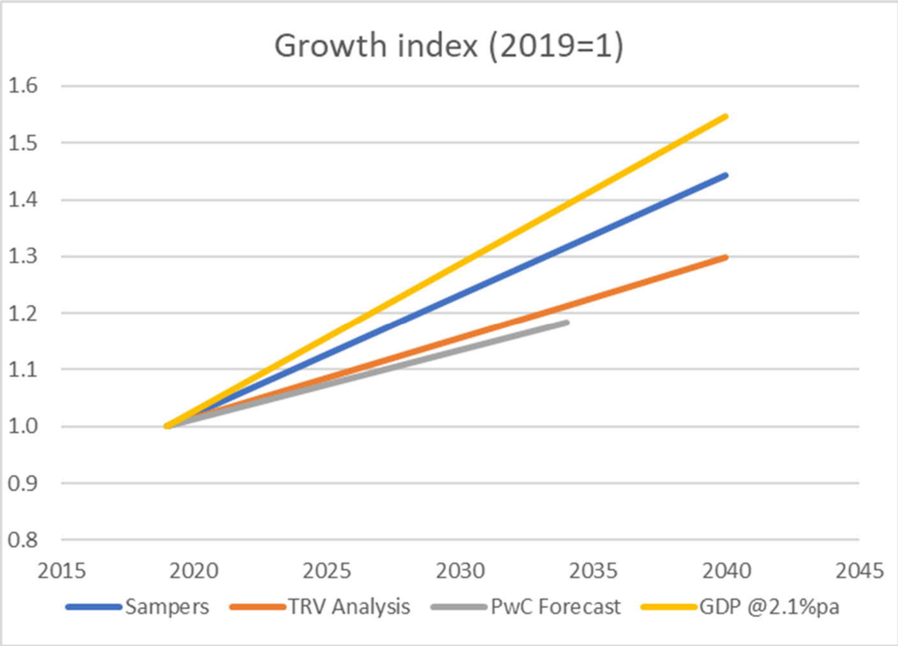
To see how the growth projections compare, it is instructive to plot the growth rates of the different forecasts. For comparison we have additionally added the growth from the PwC forecasts discussed in the previous chapter. Figure 6.6 shows the absolute underlying growth for Stockholm-Gothenburg while Figure 6.7 displays the growth index from a 2019 starting point.

Figure 6.6: Underlying Growth: Stockholm – Gothenburg (annual Trips)



Source: Jacobs analysis

Figure 6.7: Underlying Growth: Stockholm – Gothenburg (Index)

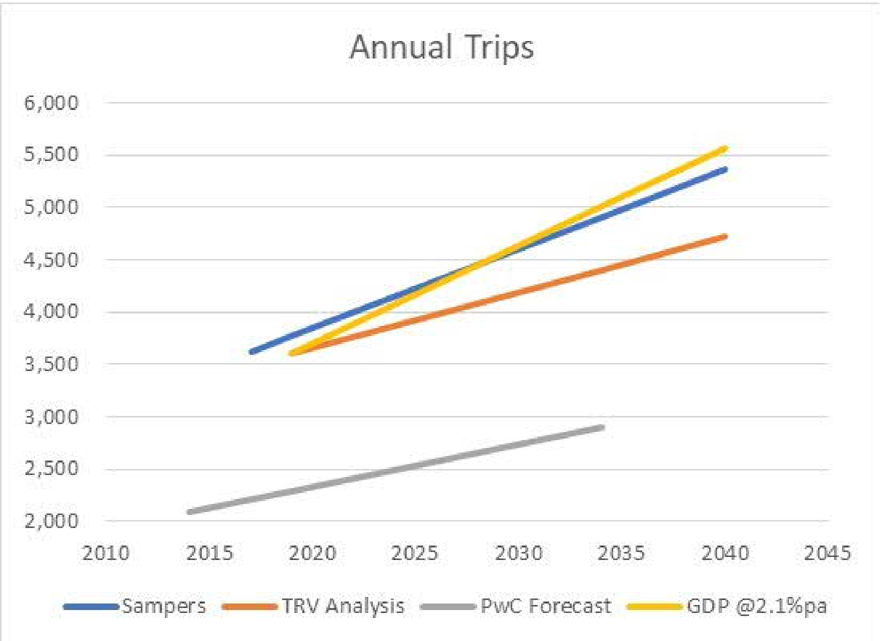


Source: Jacobs analysis

This shows that Sampers and the TRV analysis differ at their starting and end point and their difference has been exacerbated by 2040. Growth rates for both are significantly below those suggested by a 2.1% GDP projection. The PwC forecast has a much lower starting point and lower growth profile than all other projections.

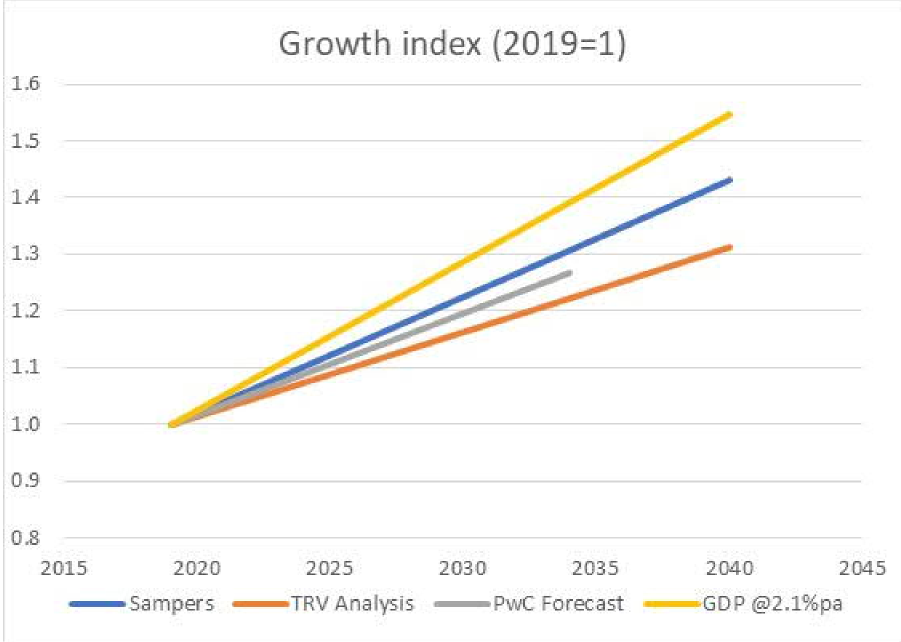
The same information is shown for the Stockholm-Malmö corridor in Figure 6.8 and Figure 6.9.

Figure 6.8: Underlying Growth: Stockholm – Malmö (annual Trips)



Source: Jacobs analysis

Figure 6.9: Underlying Growth: Stockholm – Malmö (Index)

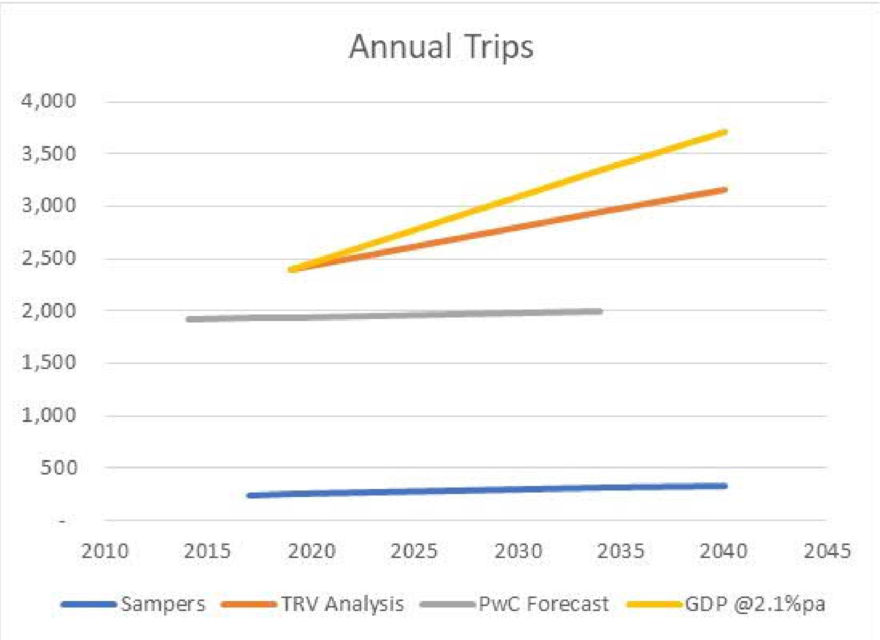


Source: Jacobs analysis

As with the Gothenburg corridor, this shows that Sampers and the TRV analysis differ at their starting and end point and their difference has been exacerbated by 2040. Growth rates for both are again significantly below those suggested by a 2.1% GDP projection. The PwC forecast has a much lower starting point but a higher growth profile than the TRV analysis.

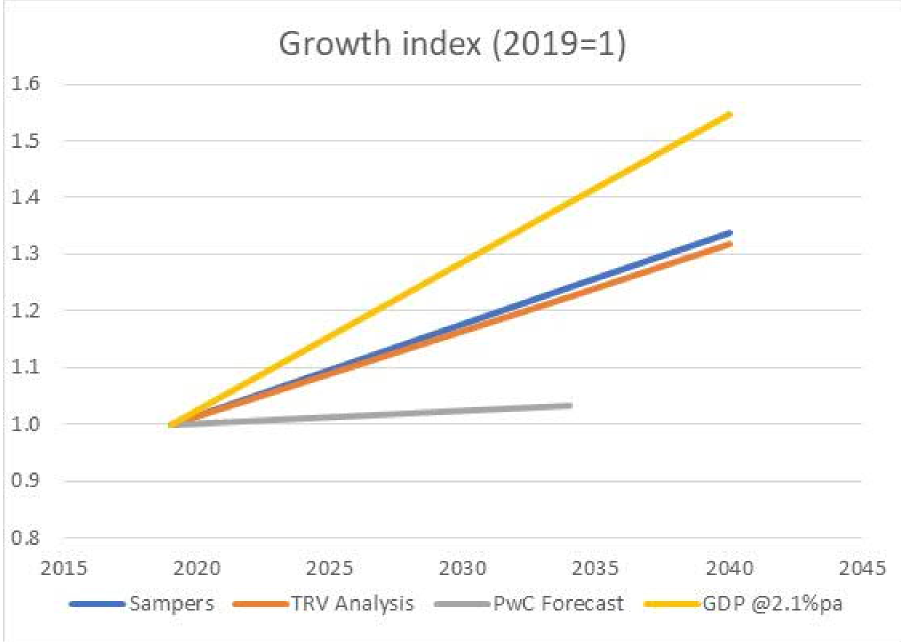
Figure 6.10 and Figure 6.11 show the same information for the Stockholm to Copenhagen corridor.

Figure 6.10: Underlying Growth: Stockholm – Copenhagen (annual Trips)



Source: Jacobs analysis

Figure 6.11: Underlying Growth: Stockholm – Copenhagen (Index)



Source: Jacobs analysis

This shows considerable divergence between the different projections but the Sampers figures are not strictly comparable as these trips are clearly not represented appropriately in the model – both in terms of their absolute number and in terms of their growth potential. The PwC growth forecasts also appear very cautious.

6.2.3 High-Speed rail forecasts

The TRV analysis of High-Speed rail demand is based on a comparison with evidence from other countries. The forecasts with the High-Speed rail project in place is contrasted with the Sampers-based forecasts in Table 6.24 to Table 6.26.

Table 6.24: Sampers and TRV Analysis HSR Forecasts (thousands), Stockholm-Gothenburg/Borås, 2040

	2040 No HSR	2040 HSR Reference Scenario (re-based)	TRV analysis 2040 no HSR	TRV analysis 2040 with HSR
Car	5,230	5,089	3,100	2,200
Bus	410	396	100	100
Air	1,350	1,251	1,500	400
Train	2,930	4,868	2,800	6,400
Total	9,920	11,604	7,400	9,100

Source: Sampers and Jacobs interpretation of TRV analysis

Table 6.25: Sampers and TRV Analysis HSR Forecasts (thousands), Stockholm-Malmö/Lund, 2040

	2040 No HSR	2040 HSR Reference Scenario (re-based)	TRV analysis 2040 no HSR	TRV analysis 2040 with HSR
Car	2,340	2,293	1,540	1,440
Bus	290	290	30	30
Air	1,460	1,393	1,820	670
Train	1,270	2,091	1,320	2,860
Total	5,360	6,067	4,720	4,990

Source: Sampers and Jacobs interpretation of TRV analysis

Table 6.26: Sampers and TRV Analysis HSR Forecasts (thousands), Stockholm-Copenhagen, 2040

	2040 No HSR	2040 HSR Reference Scenario (re-based)	TRV analysis 2040 no HSR	TRV analysis 2040 with HSR
Car	0	0	980	960
Bus	0	0	-	-
Air	0	0	1,550	980
Train	330	330	630	1,340
Total	330	330	3,160	3,290

Source: Sampers and Jacobs interpretation of TRV analysis

The key difference between the two sets of projections is a higher corridor total for all modes in the Sampers forecasts but a higher rail demand projection in the TRV analysis in both the Swedish corridors. On the Copenhagen route, the TRV analysis shows a much higher projection.

The resulting mode shares in the forecasts with High-Speed rail in place are summarised in Table 6.27 to Table 6.29.

Table 6.27: Sampers and TRV Analysis Mode Shares, Stockholm-Gothenburg/Borås, 2040

	2040 HSR Reference Scenario (re-based)	Market Share (%)	TRV analysis 2040	Market Share (%)
Car	5,089	44%	2,300	25%
Bus	396	3%	-	-
Air	1,251	11%	400	4%
Train	4,868	42%	6,400	70%
Total	11,604	100%	9,100	100%

Source: Sampers and Jacobs interpretation of TRV analysis

Table 6.28: Sampers and TRV Analysis Mode Shares, Stockholm-Malmö/Lund, 2040

	2040 HSR Reference Scenario (re-based)	Market Share (%)	TRV analysis 2040	Market Share (%)
Car	2,293	38%	1,470	29%
Bus	290	5%	-	-
Air	1,393	23%	670	13%
Train	2,091	34%	2,860	57%
Total	6,067	100%	4,990	100%

Source: Sampers and Jacobs interpretation of TRV analysis

Table 6.29: Sampers and TRV Analysis Mode Shares, Stockholm-Copenhagen, 2040

	2040 HSR Reference Scenario (re-based)	Market Share (%)	TRV analysis 2040	Market Share (%)
Car	Cannot be meaningfully calculated because Sampers only contains rail demand to Copenhagen		960	29%
Bus			-	-
Air			980	30%
Train			1,340	41%
Total			3,290	100%

Source: Sampers and Jacobs interpretation of TRV analysis

This shows that the TRV analysis projections predict that High-Speed rail is able to capture market share much more aggressively than the Sampers forecast. While Sampers suggests that rail will capture only between 34% and 42% of the total market in the Swedish corridors, the TRV analysis predicts between 57% and 70%, and 41% for the Copenhagen route.

It is instructive to examine where the High-Speed rail demand has been extracted from in both sets of forecasts. This is summarised in Table 6.30 to Table 6.32.

Table 6.30: Origin of High-Speed Rail Demand, Stockholm-Gothenburg/Borås, 2040

	2040 HSR Reference Scenario (re-based)	% of new rail demand	TRV analysis 2040 with HSR	% of new rail demand
From Car	141	3%	900	14%
From Bus	14	0%	-	-
From Air	99	2%	1,100	17%
From Train	2,930	60%	2,800	44%
Generated Demand	1,684	35%	1600	25%
Total	4,868	100%	6,400	100%

Source: Sampers and Jacobs interpretation of TRV analysis

Table 6.31: Origin of High-Speed Rail Demand, Stockholm-Malmö/Lund, 2040

	2040 HSR Reference Scenario (re-based)	% of new rail demand	TRV analysis 2040 with HSR	% of new rail demand
From Car	47	2%	100	3%
From Bus	0	0%	-	-
From Air	67	3%	1,150	40%
From Train	1,270	61%	1,320	46%
Generated Demand	707	34%	290	10%
Total	2,091	100%	2,860	100%

Source: Sampers and Jacobs interpretation of TRV analysis

Table 6.32: Origin of High-Speed Rail Demand, Stockholm-Copenhagen, 2040

	2040 HSR Reference Scenario (re-based)	% of new rail demand	TRV analysis 2040 with HSR	% of new rail demand
From Car	0	0%	20	1%
From Bus	0	0%	-	-
From Air	0	0%	570	43%
From Train	330	100%	630	47%
Generated Demand	0	0%	120	9%
Total	330	100%	1,340	100%

Source: Sampers and Jacobs interpretation of TRV analysis

This shows a significant difference in the two sets of predictions. While both agree that the majority of High-Speed rail demand will come from existing rail patronage, like the PwC forecast, the TRV analysis projection sees a much higher abstraction from air in both Swedish corridors and from car in the Stockholm to Malmö corridor than Sampers. By contrast, Sampers predicts a much higher level of generated demand, especially on the Stockholm to Malmö route.

The TRV analysis is informed by an analysis of the Paris-Lyon and Rome-Milan routes before and after the introduction of High-Speed rail services. The comparison is not straightforward because in both cases the pre- and post-HSR data come from several years apart and it is difficult to separate general growth in the corridor from demand generated by the introduction of High-Speed rail. However, it indicates that in the Paris-Lyon case, the majority of HSR trips come from existing train services and generated demand while in the Milan-Rome case, the majority come from existing train services and air.

In this context it is instructive to examine the air/rail shares in the TRV analysis projections compared with those shown for the Sampers and PwC forecasts. The figures for the TRV analysis projections are presented in Table 6.33.

Table 6.33: TRV Analysis 2040 New Lines Projection (thousands) for Air/Rail Shares

TRV analysis	Air Demand	Rail Demand	Air Share	Rail Share
Stockholm-Gothenburg	400	6,400	6%	94%
Stockholm-Malmö	670	2,860	19%	81%
Stockholm-Copenhagen	980	1,340	42%	58%
For comparison: Paris-Lyon			10%	90%
For comparison: Rome-Milan			18%	82%

Source: Jacobs interpretation of TRV analysis

This shows a similarly high capture of the combined market by rail for both corridors compared with the PwC forecasts (Table 6.21) but much higher proportions than the Sampers forecasts (Table 5.9).

On the Stockholm-Gothenburg route, 94% of demand falls to rail and on the Stockholm-Malmö route it is 81%. Both are within the range of the international comparison shown in chapter 5. As in the PwC forecasts, rail penetration is lower for travel to Copenhagen at 58%.

6.3 The UK Passenger Demand Forecasting Handbook (PDFH)

To add to the evidence base, we have also prepared an additional comparator projection using parameters from the UK Passenger Demand Forecasting Handbook (PDFH). We have not fully assessed the applicability of PDFH-based calculations for the Swedish market and these projections are only shown for comparative purposes. The PDFH calculations are a projection of potential High-Speed rail demand from a future base situation only and do not include growth projections from a base year.

The UK PDFH has been developed over several years using scientific, statistical and empirical approaches to consider how various exogenous and endogenous factors affect rail demand. This research and the formulae and methods thus developed have formed the backbone of rail forecasting in the UK, in use by the Department for Transport and Train Operating Companies.

PDFH uses an elasticity-based approach to forecasting and has a range of different elasticity values for different demand drivers and different markets.

In the PDFH approach, change in demand can be projected as a function of Generalised Journey Time (GJT):

$$I_j = \left(\frac{GJT_{new}}{GJT_{base}} \right)^j$$

Where:

- I_j is the index for the change in volume due to journey time related factors
- j is the generalised journey time elasticity
- GJT_{base} and GJT_{new} are the base and new generalised journey times
- GJT is made up of in-vehicle time and a service interval penalty (plus an interchange penalty – not relevant here)

Increase in demand as a function of reliability:

$$I_R = \left(\frac{APM_{new}}{APM_{base}} \right)^{e_{APM}}$$

- I_R is the index for the change in volume due to reliability changes
- APM_{new} and APM_{base} are the "Average Performance Minutes" for the new and original demand
- e_{APM} is the elasticity for the relevant rail market with regard to reliability

PDFH provides "service interval penalties" ranging from 5 to 70 minutes for service intervals ranging from 5 to 180 minutes. This is in effect a non-linear wait time function where wait times do not increase in proportion with headway as people tend not to arrive at random for less frequent services but time their arrival.

The "Average Performance Minutes" (APM) are based on the proportion of trains that are late and the amount of lateness. With the Swedish definition of "late" if the train is 6 minutes behind schedule, we have assumed that the "average lateness" of a "late" train is 12 minutes. Based on this assumption, at reliability of 65%, the APM is (12*35%) = 4.2 mins and at 95%, APM is (12*5%) = 0.6 mins. For reliability, an elasticity value of around -0.11 is consistently given for long distance journeys irrespective of market segment or journey purpose.

In contrast, for GJT, a wide range of elasticity values are quoted. The lowest (absolute) value for long distance journeys is -1.20. Higher elasticities are applicable for connections with strong air competition. In PDFH, the highest values are quoted for "London flows with strong air competition". In the UK, this applies predominantly to connections with Glasgow and Edinburgh (both with a base rail journey time of around 4.5 hours) and to a more limited extent to connections with Aberdeen and Manchester. If these elasticities were applicable to the Swedish market, based on the base rail GJT, we would calculate a high elasticity of -2.03 for Stockholm-Gothenburg, -2.92 for Stockholm-Malmö and -4.12 for Stockholm-Copenhagen. However, an analysis of the existing and projected air demand for the three corridors suggests that these elasticities would not be plausible: there is not as much air demand available to transfer to rail as would be suggested by the application of these elasticities. Based on the available air demand, we have calculated the maximum plausible elasticities for the three corridors to be -1.71, -1.91 and -2.66 respectively.

We have used these PDFH principles and parameters to estimate possible HSR demand in Sweden using the 2040 rail demand total without HSR from the TRV analysis projection as the base together with the journey time and frequency improvements of the 2040 HSR Reference Scenario as described in chapter 4 and assumed reliability improvements as communicated to us by Trafikverket. These are summarised in Table 6.34.

Table 6.34: Assumed Train Service Reliability Levels in 2040 without and with HSR

	No HSR	With HSR
Stockholm-Gothenburg	70%	95%
Stockholm-Malmö	65%	95%
Stockholm-Copenhagen	65%	95%

Source: Trafikverket

The resulting projection is shown in Table 6.35, giving a "low" projection based on cautious elasticity value of -1.2 and a "high" projection using the maximum plausible elasticity values outlined above.

Table 6.35: Indicative Projection based on PDFH (2040)

	No HSR	With HSR low	With HSR high
Stockholm-Gothenburg	2,800	5,857	7,357
Stockholm-Malmö	1,320	3,380	5,199
Stockholm-Copenhagen	630	1,427	2,977

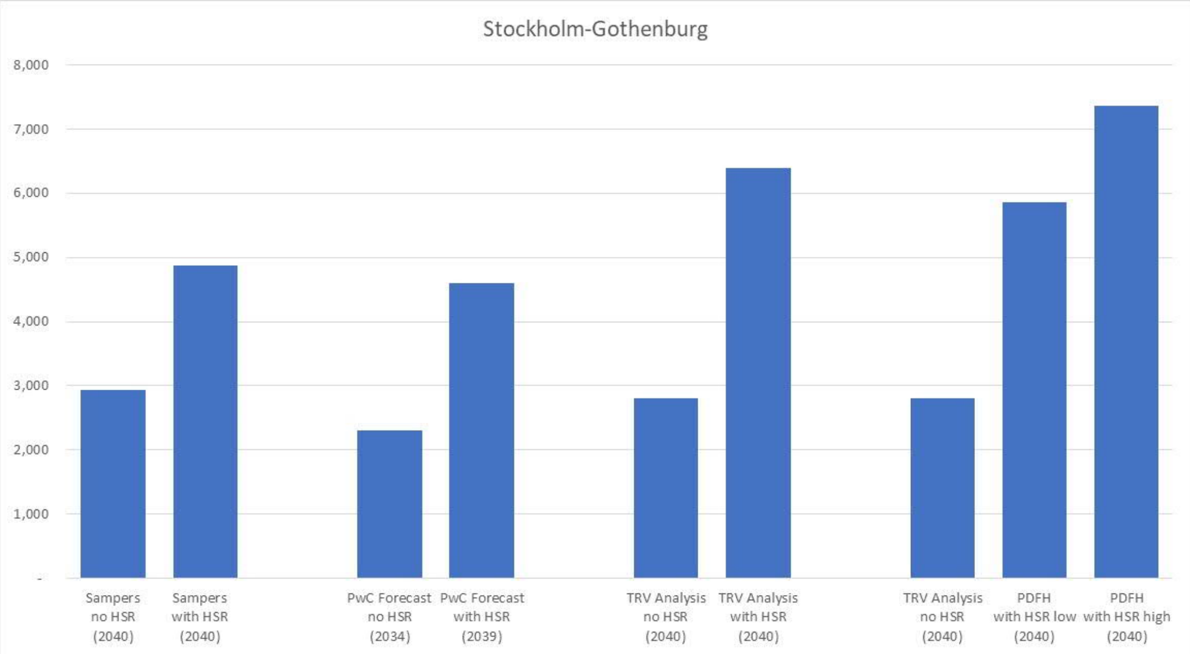
Source: Jacobs Analysis

It should be noted that this is for comparative purposes only – we have not assessed the applicability of the PDFH for the Swedish market. Furthermore, PDFH does not give guidance on a "border effect" for foreign travel and the calculation of demand to Copenhagen is based on domestic travel parameters which may produce an overestimate.

6.4 Comparison of available forecasts of High-Speed rail demand

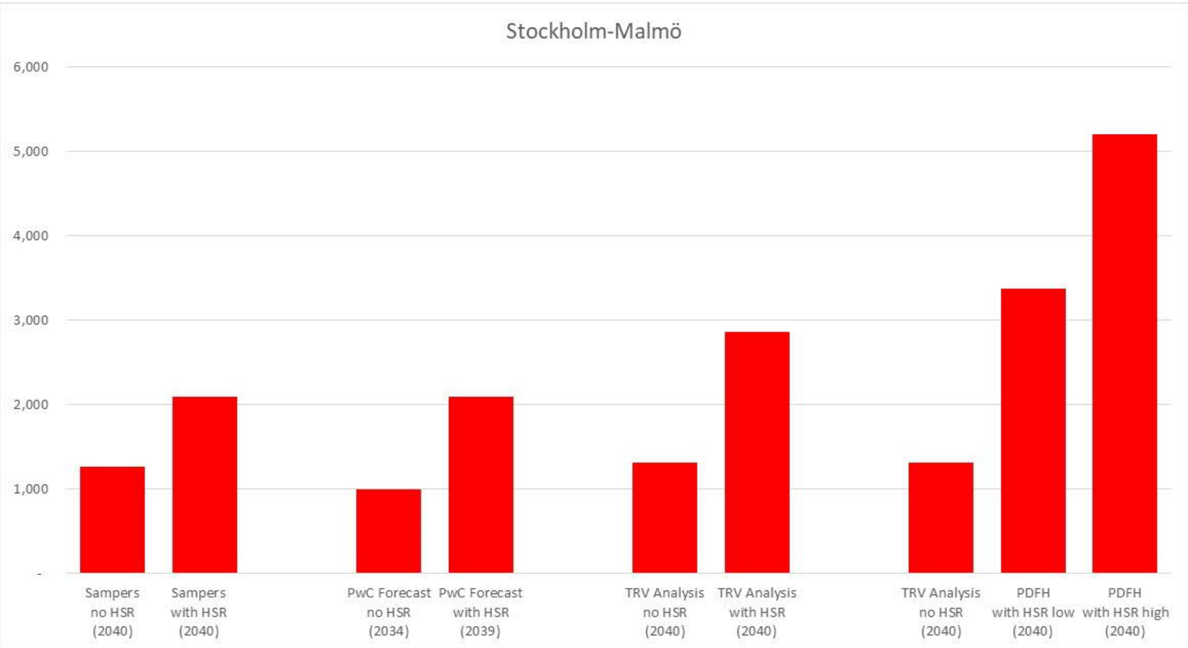
Figure 6.12 to Figure 6.14 show a comparison of forecasts for the three corridors.

Figure 6.12: Comparison of Forecasts: Stockholm-Gothenburg



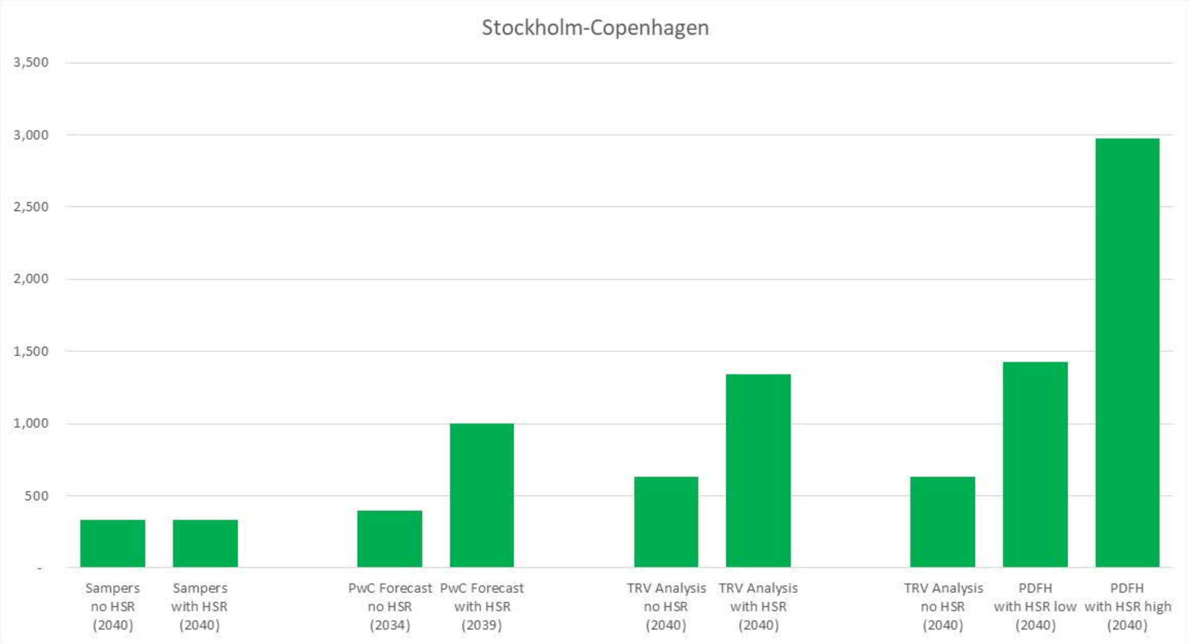
Source: Jacobs analysis

Figure 6.13: Comparison of Forecasts: Stockholm-Malmö



Source: Jacobs analysis

Figure 6.14: Comparison of Forecasts: Stockholm-Copenhagen



Source: Jacobs analysis

We observe in these comparisons that for Stockholm-Gothenburg, Sampers and PwC forecast produce lower forecasts than the TRV analysis or PDFH projections. The TRV analysis totals lie in between the low and high projection from PDFH.

For Stockholm-Malmö, Sampers and PwC forecast produce very similar forecasts (but from different no-HSR starting points). The TRV analysis projections are higher from a similar no-HSR starting point compared with Sampers. In this corridor, the PDFH method would project a higher total even using the low elasticity assumption.

For Stockholm-Copenhagen, the Sampers forecast appear inappropriately low. Our understanding is that the reasons for this are threefold:

- The absence of other (non-rail) demand in the model from which High-Speed rail could abstract trips;
- An underrepresentation of rail demand to Copenhagen in the base year; and
- No growth in demand being assumed between base and forecast year.

PWC forecast project a much higher rail demand level in the with-HSR scenario. The TRV analysis projection is higher still and very similar to the PDFH low projection.

The PDFH high projections are significantly higher than the other forecasts in all corridors. Although we have adjusted the possible high elasticities for all three corridors to plausible values that do not overpredict transfer from air beyond the available air demand, these should be seen as a high end potential demand level rather than a forecast – especially for the longer journeys Stockholm-Malmö and Stockholm-Copenhagen.

6.5 Balance between journey time, punctuality and frequency

The TRV analysis applies weights to the level of improvement for each of the factors journey time, frequency and reliability. These three factors are also the drivers of demand in the PDFH approach.

Improvements in these factors vary by corridor:

- Stockholm-Gothenburg: Projected improvements range from 30% (frequency) to 36% (punctuality);

- Stockholm-Malmö: Projected improvements range from 40% (journey time) to 46% (punctuality); and
- Stockholm-Copenhagen: Projected improvements range from 11% (frequency) to 46% (punctuality)

The contribution made by the different factors to the TRV analysis projection and the PDFH projection for the Stockholm-Gothenburg corridor is illustrated in Figure 6.15 and Figure 6.16.

Figure 6.15: Balance between Factors, TRV Analysis: Stockholm-Gothenburg

Source: Jacobs analysis

Figure 6.16: Balance between Factors, PDFH Projection: Stockholm-Gothenburg

Source: Jacobs analysis

The contribution made by the different factors to the TRV analysis projection and the PDFH projection for the Stockholm-Malmö corridor is illustrated in Figure 6.17 and Figure 6.18.

Figure 6.17: Balance between Factors, TRV Analysis: Stockholm-Malmö

Source: Jacobs analysis

Figure 6.18: Balance between Factors, PDFH Projection: Stockholm-Malmö

Source: Jacobs analysis

The contribution made by the different factors to the TRV analysis projection and the PDFH projection for the Stockholm-Copenhagen corridor is illustrated in Figure 6.19 and Figure 6.20.

Figure 6.19: Balance between Factors, TRV Analysis: Stockholm-Copenhagen

Source: Jacobs analysis

Figure 6.20: Balance between Factors, PDFH Projection: Stockholm-Copenhagen

Source: Jacobs analysis

Because the improvements vary only by a small amount between the three factors and frequency weighting is low, their weighting in the TRV analysis does not affect the outcome very much. In the PDFH projection, the impact of journey time is generally higher and the impact of reliability is lower than in the TRV analysis. The impact of journey time becomes dominant in the PDFH high projection.

6.6 Importance of journey time targets

A travel time below 3 hours is regarded as an important threshold in much of the literature where:

- Rail becomes dominant in the rail/air competition; and
- Business day-trips are considered possible.

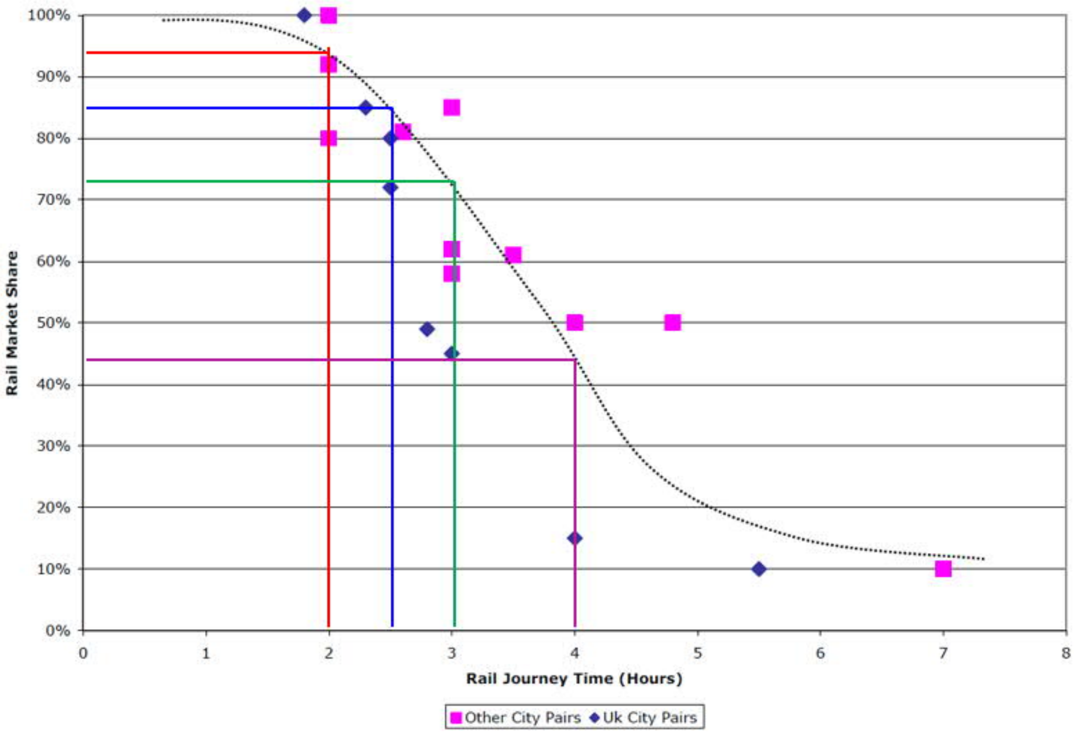
This effect can be observed, for example, on the Paris to Lyon line when it first fell from 3 to 2 hours which led to a substantial increase in travel demand, London-Brussels and Paris-Brussels (both ≈2 hours) and London-Paris (≈2½ hours) where rail is now dominant.

There is regional variation based on the economic circumstances. Connecting two cities of importance in terms of administrative, commercial and technical development, the Paris to Lyon line has had a high business demand which has benefitted from the reduction of journey times to two hours.

Areas with a lower economic activity between them do not necessarily respond as sharply to reaching a journey time below 3 hours. An example is the Paris-Marseilles line which has seen a significant improvement at the 3-hour mark as the demand on this line is more driven by tourism. (After the arrival of TGV between Marseille and Paris in 2001, rail market share rose from below 50% to nearly 70% by 2004).

The relationship between rail journey time and the rail share of the combined rail/air market has been explored extensively in the literature and some of this material is reproduced in section 5.6. A similar graph is presented in PDFH and this has been annotated with expected modal shares at rail journey times of 4 hours, 3 hours 2½ hours and 2 hours as shown in Figure 6.21.

Figure 6.21: Rail Share of the Rail/Air Market as a Function of Rail Journey Time



Source: Jacobs annotation of graph from PDFH

This shows that:

- At 2 hours rail captures ≈ 94% of the combined air/rail market;
- At 2½ hours it is ≈ 85%;
- At 3 hours it is ≈ 72%; and
- At 4 hours it drops below 50%.

This indicates that achieving a rail journey time of 3 hours is important in the competition with air. Further improvements towards 2 hours will generate further gains but the returns for the extra improvements are diminishing.

6.7 Corridor prioritisation

Both corridors are clearly important and are the key corridors that rail investment should focus on. The difference between the two corridors can be summarised simplistically as follows:

- Stockholm-Gothenburg has the larger present day demand and larger forecast demand; but
- Stockholm-Malmö has potentially more growth potential, serves more intermediate conurbations and provides access to Copenhagen.

If a choice is to be made between investment priorities to achieve shorter journey times on either corridor, on balance, our view is that achieving 2h30mins for Stockholm-Malmö is more important than 2h00mins for Stockholm-Gothenburg because:

- Train should be the dominant mode at 2h30mins or less – further reductions towards 2h00mins bring marginal benefits; and
- Achieving 2h30mins for Stockholm-Malmö allows the possibility of getting Stockholm-Copenhagen close to 3 hours.

While the Stockholm-Gothenburg market is clearly larger than the Stockholm-Malmö market, it is the possibility of capturing further market share from the Stockholm-Copenhagen connection that suggests a focus on this route, especially as the analysis so far indicates that there is much greater potential for this than is predicted in the Sampers-based forecasts. We provide further thoughts on demand for intermediate stations in chapter 7 and further thoughts on demand potential for travel to Copenhagen in section 9.3.

6.8 Importance of small time savings

The definition of the RU1 to RU4 scenarios introduces the potential for further time savings for the end-to-end connections from Stockholm to Gothenburg and Malmö (as well as Copenhagen). In the RU3 scenario which has the largest journey time improvement, such further time savings amount to 10 minutes for the corridors to Malmö and Copenhagen and 12 minutes for the corridor to Gothenburg.

As our analysis shows, journey time elasticities are high, especially in corridors with strong air competition, indicating that further time savings could have a material effect on forecasts. However, elasticities decline with shorter journey length. Depending on the characteristics of the corridor (and particular the level of air competition), a 10 mins time saving could be estimated to give increases in rail demand of between 6% and 12% for journeys between 2 and 3 hours on the basis of journey time elasticities. How much of this will materialise depends on available alternatives for each origin-destination pair and a discrete choice model (like Sampers) is good at considering those alternatives and providing an appropriate forecast. The available forecasts from Sampers suggest an increase for scenario RU3 compared to the (re-based) HSR Reference Scenario of 6% in the Gothenburg corridor and 16% in the Malmö corridor which is in line with expectations based on journey time elasticities.

7. Demand at Intermediate Stations

7.1 Background

While end-to-end demand has been a focus of our analysis, regional demand also forms an important part of the justification for the scheme. This includes both, demand between the key end station and smaller conurbations in between and demand between the smaller conurbations themselves. The size of this intermediate demand is an important consideration in the route planning, when, for example, a decision is required between a station in the centre or the outskirts of a town or between different option for stopping patterns.

7.2 Present day regional demand

Table 7.1 shows the regional demand between a number of regional destinations for 2019.

Table 7.1: Number of passengers (millions) between a number of destinations, 2019, pre-Covid

	Total	Train	Bus	Car
Stockholm - Linköping	2.8	50%	10%	40%
Stockholm - Norrköping	2.6	45%	10%	45%
Gothenburg - Linköping	0.6	15%	10%	75%
Gothenburg - Norrköping	0.4	20%	10%	70%
Gothenburg - Jönköping	0.8	8%	20%	72%
Malmö - Linköping	0.3	60%	10%	30%
Malmö - Jönköping	0.3	30%	10%	60%
Linköping - Borås	0.1	2%	8%	90%
Norrköping - Borås	0.1	2%	4%	94%
Stockholm - Nyköping	2.5	30%	10%	60%
Stockholm - Trosa	0.7	10%	20%	70%
Gothenburg - Borås	5.0	10%	40%	50%
Malmö - Hässelholm	1.0	40%	1%	59%
Malmö - Kristianstad	1.3	20%	20%	60%
Linköping - Norrköping	3.0	30%	15%	55%
Linköping - Jönköping	0.8	5%	10%	85%
Linköping - Tranås	0.4	30%	5%	65%
Linköping - Nyköping	0.3	20%	10%	70%
Norrköping - Jönköping	0.5	10%	10%	80%

Source: Jacobs analysis of Trafikverket data

This suggests that the strongest regional movements are observed for the following connections:

- Stockholm – Linköping;
- Stockholm – Norrköping;
- Stockholm – Nyköping;
- Gothenburg – Borås;
- Malmö – Hässelholm;

- Malmö – Kristianstad; and
- Linköping – Norrköping.

While the majority of these movements will be served by the new lines, Kristianstad will not be. The strongest 2019 rail shares are found for the following connections:

- Stockholm – Linköping;
- Stockholm – Norrköping;
- Malmö – Linköping; and
- Malmö – Hässelholm.

7.3 Demand for intermediate station connections in the Sampers Forecasts

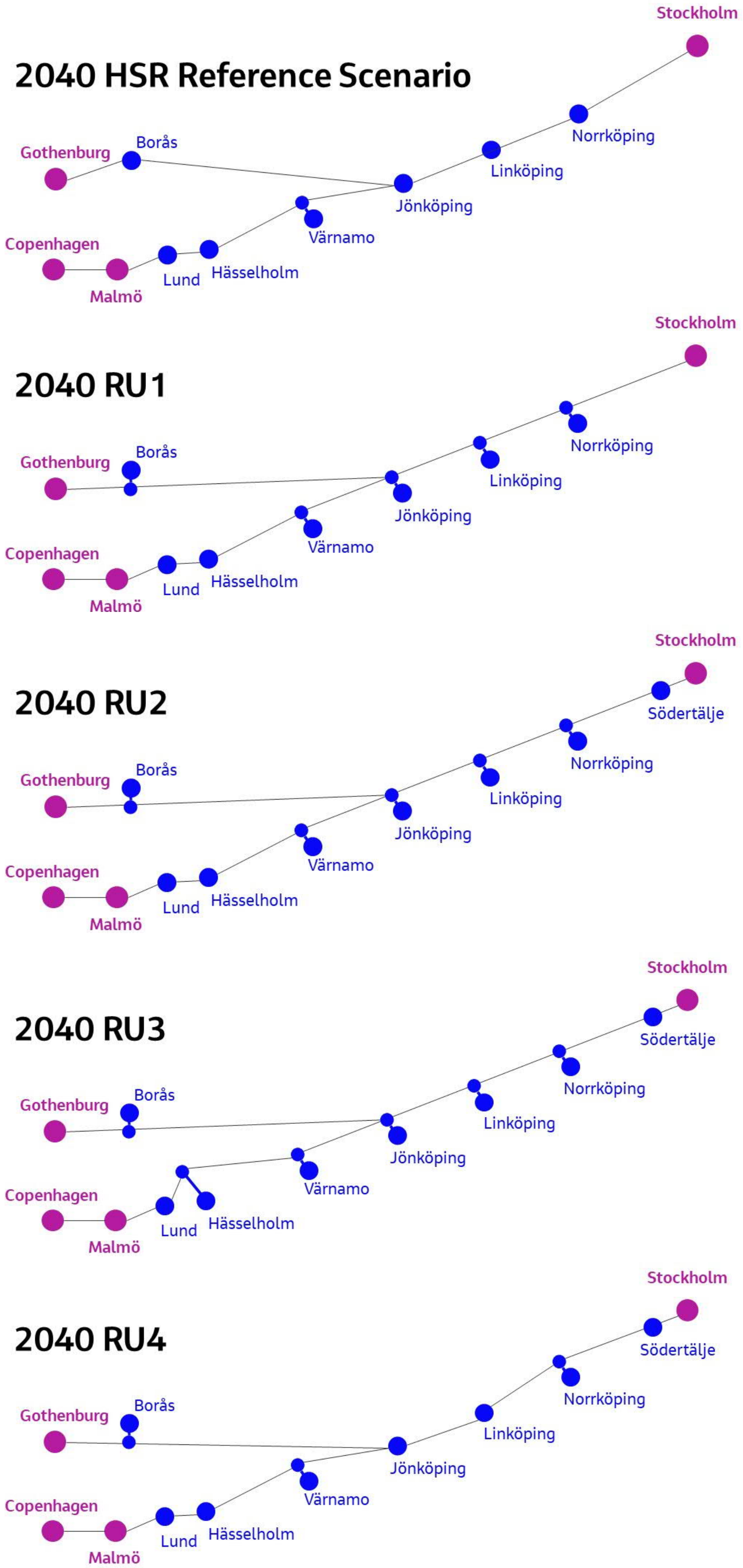
The different scenarios for the New Lines project differ with regard to the level of accessibility they provide for intermediate stations. A high-level summary of journey times and end-to-end service levels is provided in Table 5.5. The key differences between the scenarios can be summarised as follows:

- 2040 HSR Reference Scenario: Main cities at intermediate points on the route are served by some, but not all High-Speed services, with track infrastructure allowing for non-stop services to bypass stations and slower High-Speed services. Stations are located in the centre of cities, rather than at “parkway” stations. Some local connecting services also use the High-Speed rail infrastructure.
- RU1 is similar to the main option but with external stations at Norrköping, Linköping, Jönköping and Borås.
- RU2 also has external stations at Norrköping, Linköping, Jönköping and Borås and removes regional trains from using the High-Speed network in the Stockholm area. Södertälje is introduced as an additional stop.
- RU3 also has external stations at Norrköping, Linköping, Jönköping and Borås and additionally at Hässelholm. In this scenario, regional trains are removed from using the High-Speed network everywhere.
- RU4 is a hybrid option based on RU2 that re-introduces city centre stations at Linköping and Jönköping.

In terms of stopping patterns, scenarios RU2 to RU4 have a higher service level stopping at intermediate stations than either the Reference Scenario or RU1.

Figure 7.1 provides a stylised overview of the different scenarios.

Figure 7.1: Station Locations and Stopping Patterns of different Scenarios



A summary of demand for national rail services at intermediate station connections from Sampers is presented in Table 7.2.

Table 7.2: Forecast Demand for intermediate Stations Connections (thousands), 2040

Sampers Forecast	2017 Base Year	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Stockholm LA – Norrköping LA	570	810	1,180	920	970	1,000	980
Stockholm LA – Linköping LA	570	810	1,180	920	970	1,000	980
Göteborg LA – Borås LA	210	240	330	330	390	230	390
Göteborg LA – Jönköping LA	220	320	770	880	940	980	890
Malmö/Lund LA – Kristianstad/Hässleholm LA	430	540	600	630	620	560	630
Stockholm LA – Kristianstad/Hässleholm LA	50	70	110	120	130	110	120
Stockholm LA – Jönköping LA	160	230	390	480	510	500	500
Stockholm LA – Värnamo/Gnosjö LA + Växjö och Alvesta kommun	80	120	180	180	190	190	180
Stockholm LA – Nyköping/Oxelösund LA + Trosa kommun	390	580	600	720	520	520	520
Malmö/Lund LA – Jönköping LA	230	310	510	600	610	630	590
Stockholm LA – Kalmar LA	40	60	70	70	70	70	70
Malmö/Lund LA – Linköping LA	160	200	290	290	300	310	310
Total	3,110	4,290	6,210	6,140	6,220	6,100	6,160

It is assumed that these "National Train" passengers will use only long-distance trains and the vast majority will transfer to High-Speed rail once this is in place. A direct comparison with the 2019 observed data is not possible as the 2019 data includes local train travel. However, the general pattern of strongest regional movements is consistent between the two data sources.

We note that other intermediate destinations exist, and other intermediate movements not focussed on the end points (such as Norrköping-Borås or Linköping-Värnamo) will also attract some demand. However, these demand levels are likely to be small and in part catered for by other regional trains and we understand that Table 7.2 contains the key movements that are in scope for using High-Speed rail services for all or part of the route.

Using a degree of judgement, we can allocate the regional demand at the intermediate stations from Table 7.2[17] to the two main routes from Stockholm to Gothenburg and Malmö respectively as shown in Table 7.3 and compare this to the end-to-end demand to calculate a proportion of regional demand.

Table 7.3: Forecast Demand for intermediate Stations Connections (thousands), 2040

Sampers Forecast	2017 Base Year	2040 No HSR	2040 HSR Reference Scenario (re-based)	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Stockholm-Gothenburg end-to-end demand	1,880	2,930	4,868	4,870	5,130	5,190	5,060
Stockholm-Gothenburg regional demand	1,275	1,775	2,775	2,730	2,815	2,720	2,770
Regional demand %	40%	38%	36%	36%	35%	34%	35%
Stockholm-Malmö end-to-end demand	780	1,270	2,091	2,280	2,410	2,420	2,360
Stockholm-Malmö regional demand	1,835	2,515	3,435	3,410	3,405	3,380	3,390
Regional demand %	70%	66%	62%	60%	59%	58%	59%
Total end-to-end demand (excluding Copenhagen)	2,660	4,200	6,959	7,150	7,540	7,610	7,420
Total regional demand	3,110	4,290	6,210	6,140	6,220	6,100	6,160
Regional demand %	54%	51%	47%	46%	45%	44%	45%

This shows that while demand at intermediate stations grows between the base year and the 2040 base situation, there is a drop in regional demand as a proportion of total demand between the two years. This may be a consequence of the land use patterns underlying these forecasts where the main growth is assumed to take place in the major cities, especially around Stockholm and/or changes assumed to train service patterns between the two years.

Once the High-Speed rail service is in place, there is a substantial increase in demand at intermediate stations but the increase for end-to-end demand is larger, resulting in a drop in regional demand as a proportion of total demand.

Regional travel forms a much larger part of the demand for the Malmö route compared with the Gothenburg route, both in absolute terms and as a proportion of total demand. While both routes share demand at Norrköping, Linköping and Jönköping, there are three additional stops on the Malmö route (Värnamo, Hässelholm and Lund), while on the Gothenburg route High-Speed trains are only expected to stop at Borås.

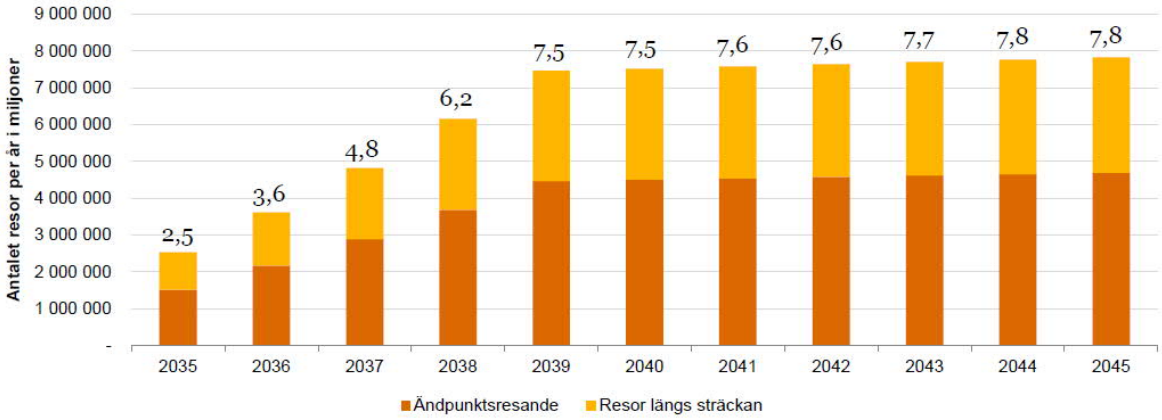
[17] While other intermediate destinations exist, we understand that Table 7.2 contains the key movements that are in scope for using high speed rail services for all or part of the route.

Of the modelled scenarios, the original HSR Reference scenario and RU2 are proving most attractive for intermediate stations while RU1, RU3 and RU4 are less attractive. The results for RU4 seem somewhat counterintuitive as the reintroduction of city centre stations at Linköping and Jönköping would be expected to increase demand from intermediate stations compared with RU2. We recommend further analysis on the model run for that scenario.

7.4 Demand for intermediate station connections in the PwC Forecasts

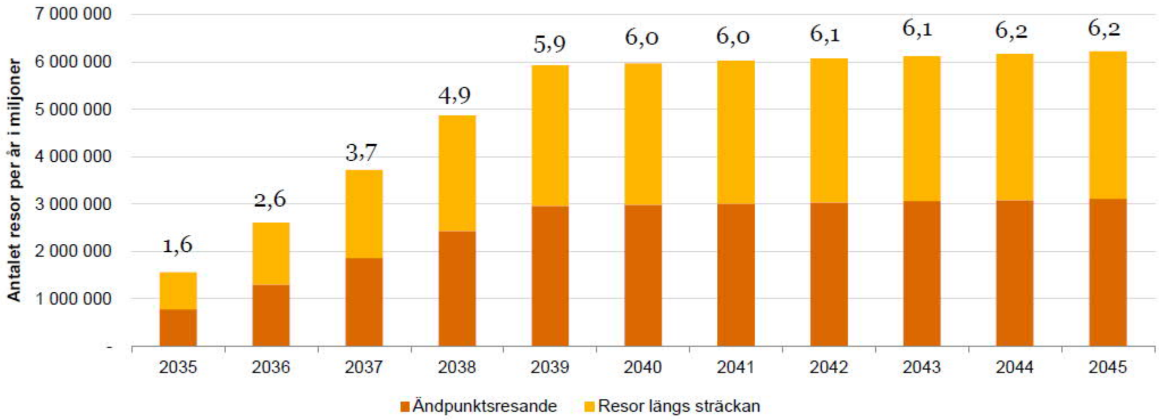
Figure 7.2 and Figure 7.3 show total annual demand for the whole routes including demand for intermediate station connections.

Figure 7.2: Stockholm-Gothenburg total annual Demand 2035-2045



Source: PwC Report (4 September 2015): Sweden Negotiation – Commercial Qualifications for High-Speed Trains in Sweden

Figure 7.3: Stockholm-Malmö/Copenhagen total annual Demand 2035-2045



Source: PwC Report (4 September 2015): Sweden Negotiation – Commercial Qualifications for High-Speed Trains in Sweden

This indicates a volume of 2.9 million annual regional trips between Stockholm and Gothenburg and 2.8 million between Stockholm and Malmö. The totals in Figure 7.3 include demand to Copenhagen. A summary of end-to-end and regional demand is provided in Table 7.4. Here we have excluded Copenhagen demand to make the figures more comparable with the Sampers analysis above.

Table 7.4: Forecast Demand for intermediate Stations Connections (thousands), 2039

PwC Forecast	2039 With HSR
Stockholm-Gothenburg end-to-end demand	4,600
Stockholm-Gothenburg regional demand	2,900
Regional demand %	39%
Stockholm-Malmö end-to-end demand	2,100
Stockholm-Malmö regional demand	2,800
Regional demand %	57%
Total end-to-end demand (excluding Copenhagen)	6,700
Total regional demand	5,700
Regional demand %	46%

This shows a similar pattern to the Sampers forecasts, with a higher absolute number and proportion of regional demand on the Malmö corridor and similar proportions of regional demand overall.

7.5 Comparison projection using a gravity approach

To offer an additional comparison, we have constructed a simple gravity model to see what levels of intermediate demand we might expect. The principle of the gravity model is that the level of trip attraction is proportional to population size but declines with distance (or journey time). Different formulations are possible for the "distance-decay", including exponential and power function or a combination of both. We have experimented with a number of formulations and have based our main analysis on a moderate distance decay function based on an exponential formulation.

We have used journey time and frequency information from the definitions of the different scenarios and have extracted population data from publicly available sources. In general, we have used population definitions for metropolitan areas or main conurbations rather than the narrower definition of towns or cities.

It should be noted that a full gravity model analysis would require a calibration of the model against actual travel demand. We have not done this, and this analysis should only be seen as indicative. The resulting proportions of demand for intermediate stations are summarised in Table 7.5.

Table 7.5: Gravity Model indicative Forecasts for intermediate Demand Proportions, 2040

Indicative Gravity Model	2040 HSR Reference Scenario	2040 RU1	2040 RU2	2040 RU3	2040 RU4
Stockholm-Gothenburg regional demand %	50%	45%	42%	42%	44%
Stockholm-Malmö regional demand %	59%	57%	54%	53%	55%
Total	53%	50%	47%	46%	48%

Compared with either the Sampers or the PwC forecasts, this shows similar proportions of intermediate station demand overall but the difference between the two corridors is smaller. In general, this also confirms the Sampers findings for the RU1 to RU4 scenarios giving lower intermediate station demand as the additional access times to out-of-town stations more than outweigh faster HSR journey times and higher frequencies.

As an additional test we have also looked at an analysis where the distance-decay function is removed, making population size the only driver of trip attraction with no distance or journey time effect. This strengthens the attraction of the large conurbation at the extremities of the lines and leads to a drop in intermediate station demand to 37% for Stockholm-Gothenburg, 46% for Stockholm-Malmö and 41% overall in the HSR Reference scenario. This could be seen as an absolute minimum of intermediate station demand that is likely to be attracted.

Predicting demand for travel from intermediate stations to Copenhagen is more difficult because of the suppressing effect of the border between Sweden and Denmark which means the economic “pull” of Copenhagen will be weaker than the population size and travel times would suggest. Our indicative calculations show that demand from intermediate stations to Copenhagen could account for up to 0.5m trips or 30% of total demand on the Stockholm to Copenhagen route (excluding trips between Malmö and Copenhagen which are local trips that will be little affected by the introduction of High-Speed rail services).

8. International Comparison

8.1 The international High-Speed rail market

In Europe, Japan and China in particular, but also in other parts of the world, High-Speed rail is considered an innovative transport mode, with numerous benefits for passengers. Often, High-Speed rail can compete with air travel on speed, especially for city centre to city centre journeys. It is a comfortable, safe, flexible, and environmentally sustainable means of transport.

High-Speed rail ridership has been increasing rapidly since its inception in the second half of the 20th century. However, the benefits of transport infrastructure investment on travel time reduction have spatial limits. As the literature suggests, when the travel distance is less than 150 km, the competitive advantage of HSR over conventional rail is decreased drastically by station processing time and by travel to and from stations. When the travel distance is longer than 800 km, the faster speed of air travel compensates for slow airport processing times and for access and egress time.

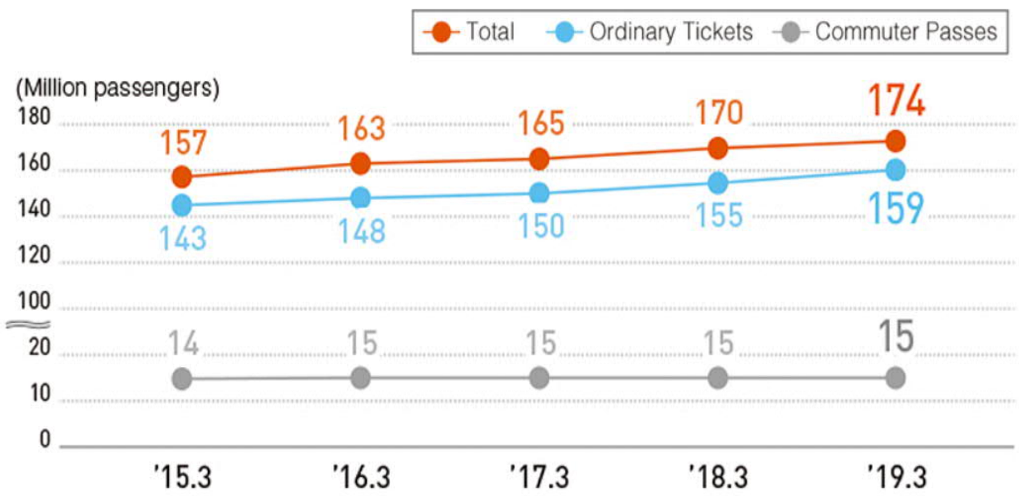
There is great variation in High-Speed rail supply between countries, both in terms of lengths of network, demand, construction cost and travel fees. In the following we provide a high level overview of the High-Speed rail scene in different countries.

8.1.1 Japan

The first High-Speed railway to be built, the Shinkansen, originally only connected Tokyo to Osaka via Nagoya, then expanded over the years to a network covering almost 3,000km. Its introduction did not cause a significant modal shift as most long-distance travel was already done by rail at the time of its inception.

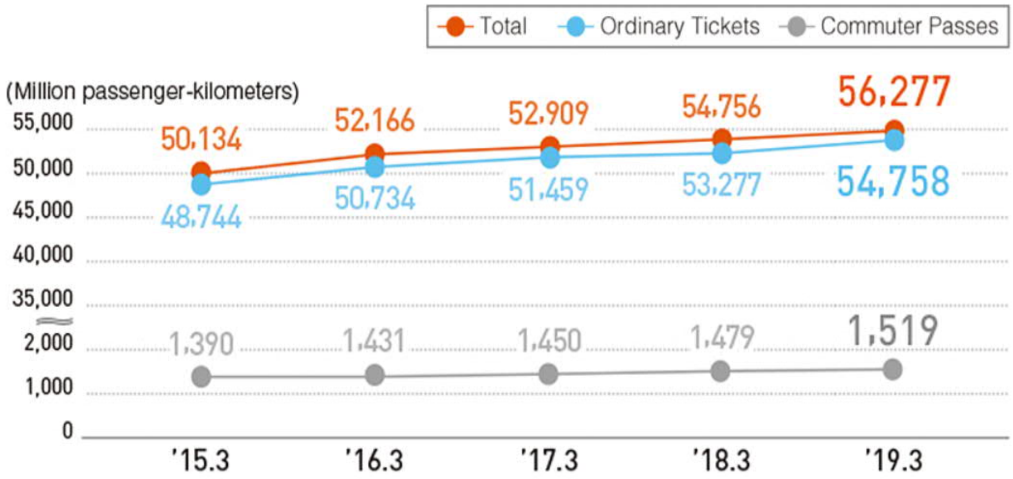
The Shinkansen currently carries around 174m passengers per year as equating to 56.3bn passenger kilometres. Over the past 5 years, travel demand has been growing by 2.6% per year on average, shown in Figure 8.1 and Figure 8.2.

Figure 8.1: Annual Passenger Demand (Million pax)



Source: Financial and Transportation Data, Central Japan Railway Company

Figure 8.2: Annual Passenger Demand (Billion pax km)



Source: Financial and Transportation Data, Central Japan Railway Company

8.1.2 Taiwan

On the Taiwanese High-Speed rail, ridership has been rising as have passenger kilometres, although they still fall short of the estimated numbers.[18] Between 2007 and 2019, demand more than quadrupled while passenger kilometres have tripled as Table 8.1 below demonstrates. After an initial jump a year after its opening in 2007, patronage has been rising at the average of 7.5% per annum.

Table 8.1: Demand and Punctuality over Time in Taiwan

Year	Ridership	Passenger km (bn)	Punctuality (less than 5 mins)
2007	15,558,356	3,520,173,426	99.47%
2008	30,581,261	6,566,119,575	99.19%
2009	32,349,260	6,863,960,208	99.25%
2010	36,939,596	7,491,019,590	99.21%
2011	41,629,303	8,147,869,493	99.87%
2012	44,525,754	8,641,573,257	99.40%
2013	47,486,229	9,118,060,276	99.38%
2014	48,024,758	9,235,162,292	99.61%
2015	50,561,954	9,654,960,687	99.66%
2016	56,586,210	10,488,339,832	99.43%
2017	60,571,057	11,103,358,620	99.72%
2018	63,963,199	11,558,787,218	99.43%
2019	67,411,248	11,994,452,919	99.88%

In terms of abstraction after its implementation in 2006, domestic air traffic decreased by 43% (by 3.7m annually) while car usage on equivalent roads have reduced by 10% by 2007.

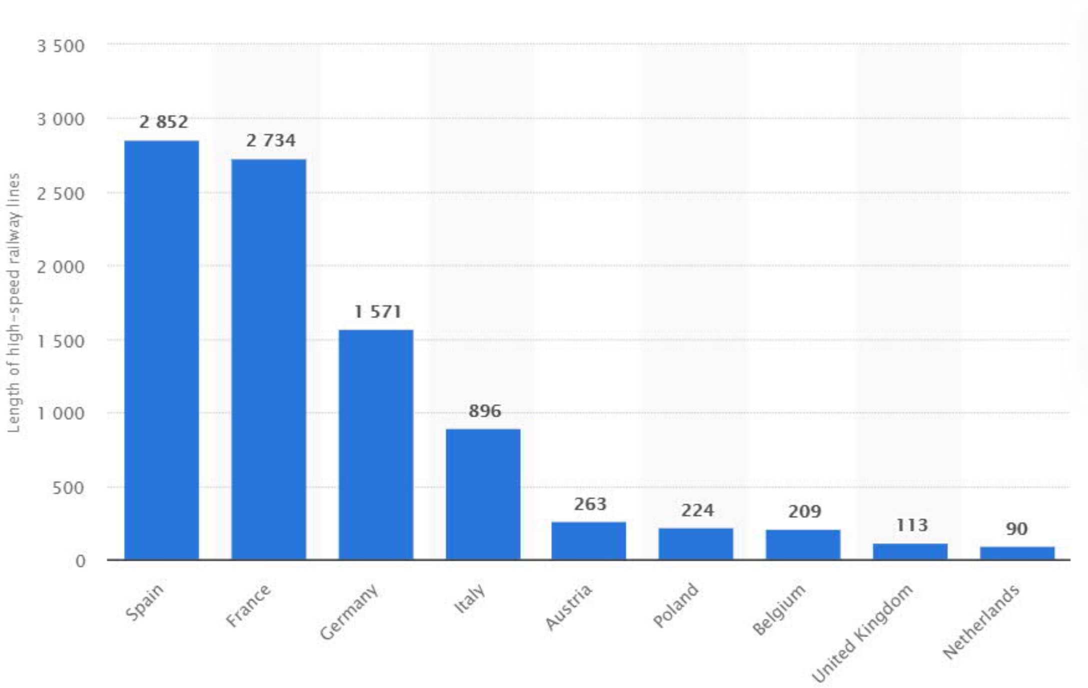
[18] http://www.ejrcf.or.jp/jrtr/jrtr48/pdf/f40_Shi.pdf

The standard ticket price on the train is NT$4.597 (€0.0297) per km currently[19], making it one of the cheapest High-Speed rail services on a distance travelled basis. While we have not undertaken any analysis of the costs of other modes and incomes in Taiwan, this would suggest that it is a particularly affordable mode in the local market.

8.1.3 Europe

The development of the European High-Speed network is mainly driven by that in Spain, France, Germany and Italy. Figure 8.3 shows the length of the High-Speed rail network that was in place by 2018.

Figure 8.3: Lengths of High-Speed Railway Network in 2018 (km)

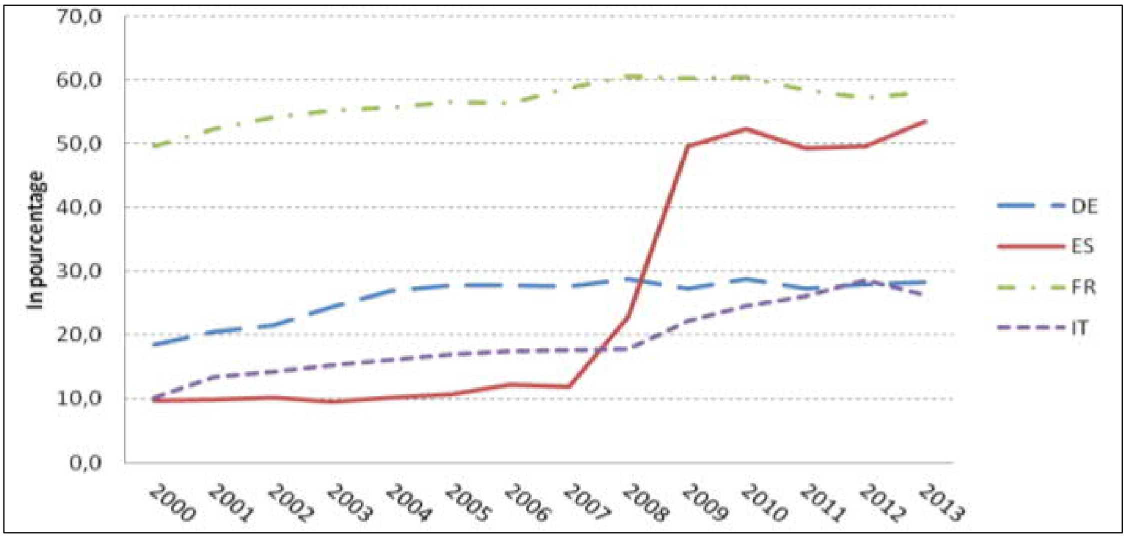


Passenger numbers vary greatly, with France hitting over 110m passengers per annum in 2017 to Spain seeing its ridership increase to only 21m in the same year and 22m in 2019, while Italy reached 43m in 2017.[20] In terms of market share of overall rail demand by passenger kilometres, High-Speed rail now exceeds 50% in both France and Spain as illustrated in Figure 8.4.

[19] https://www.taipeitimes.com/News/taiwan/archives/2019/04/04/2003712777

[20] Cascetta, Ennio & Coppola, Pierluigi. (2015). New High-Speed Rail Lines and Market Competition. Transportation Research Record: Journal of the Transportation Research Board. 2475. 8-15. 10.3141/2475-02.

Figure 8.4: High-Speed Share of the Rail Market in Germany, Spain, France and Italy



In most cases, we see air passenger demand declining as a result of the introduction of HSR, however, the spatial variation is significant. On shorter distances High-Speed rail tends to absorb demand from car and conventional train, while at larger distances (over 500km) from air demand.

8.1.4 France

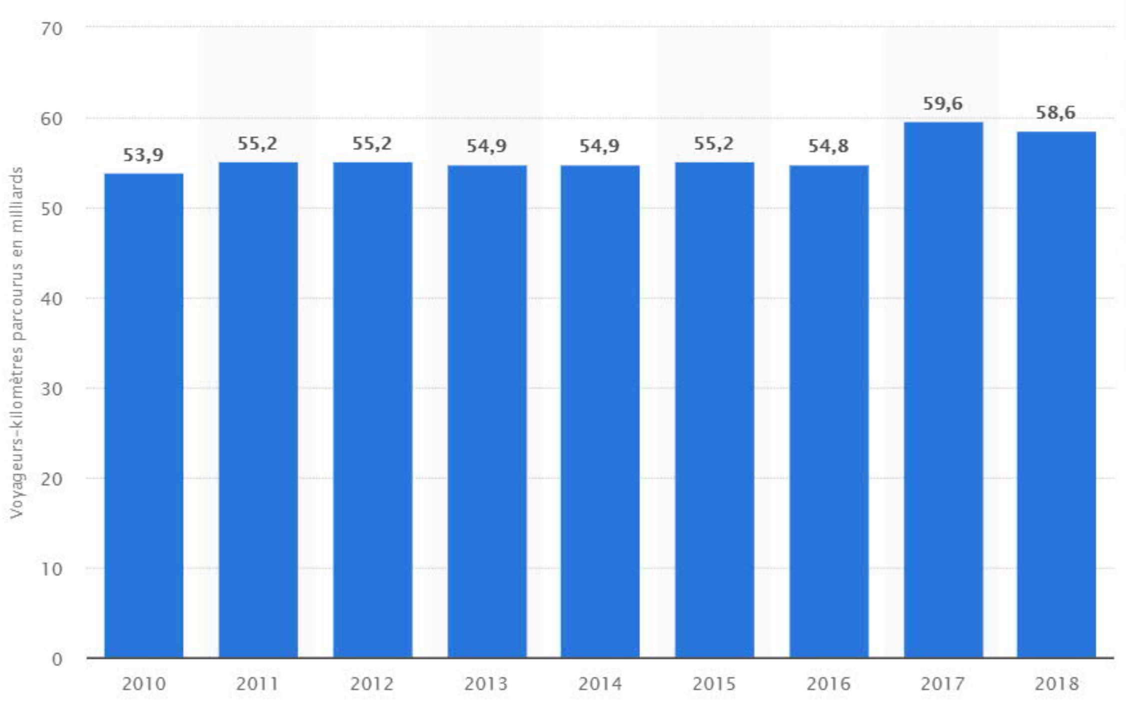
The Train à Grande Vitesse (TGV) is France's intercity High-Speed rail service, operated since 1981. A TGV test train set the world record for the fastest wheeled train, reaching 574.8 km/h, although the average speed on the network is around 160 km/h21 .

Despite the low punctuality, passenger figures have been rising steadily, with passenger numbers increasing particularly between 2017 and 2019 (11%). This is a greater growth than that experienced by traditional rail and is widely attributed to the introduction to a low-cost service (Ouigo)22.

The annual passenger kilometres can be seen in Figure 8.5 below.

[21] https://www.thelocal.fr/20171123/the-numbers-that-show-frances-proud-rail-service-is-struggling).
[22] http://www.webdisclosure.com/finance/stocks/sncf-reseau/news/885927.html

Figure 8.5: Passenger Kilometres on TGV Services between 2010 and 2018 (bn pax km)



Client satisfaction was at 77% record high in 2019[23] while the average occupancy rate is also quite high, at 67% in 2016 (compared to 25% for conventional train services).

In terms of average ticket prices, TGV sat at €0.095 per passenger per 100 km in 2016 as opposed to €0.078 for conventional services)[24].

8.1.5 Italy

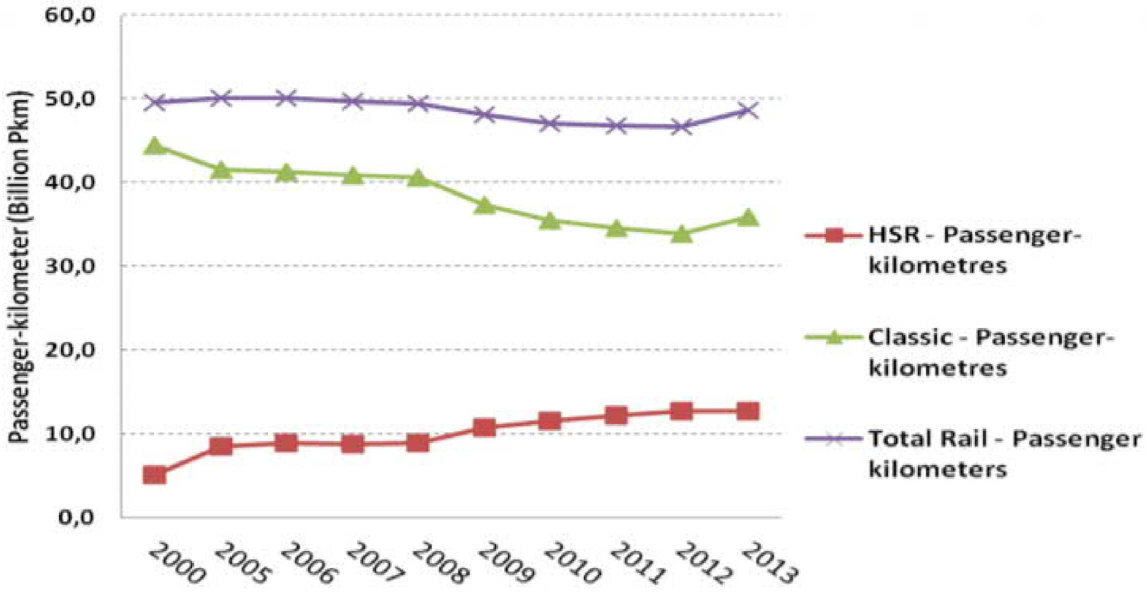
Italy's High-Speed network mainly focuses on the North, with the major lines being the Turin – Milan, Milan – Bologna, Bologna – Florence and Rome – Naples lines.

HSR demand in Italy is in increasing trend, with a major inflection point in 2009 (which corresponds to the completion of the network in its current configuration). The number of HSR passenger-kilometres increased from 8.9bn in 2008 to 10.8bn in 2009, and continued to increase with 12.8bn in 2013[25], 15.1bn in 2015 and 18.4bn in 2017.[26]

Unlike in many other countries, the Italian HSR does not seem to have drawn much demand from air traffic but from conventional rail and car (Figure 8.6). This is due to the fact that while most HSR projects connect pairs of cities at a large distance (500-700km), the Italian HSR network connects mainly medium and large metropolitan areas in the range of 100-150 km.

[23] http://www.webdisclosure.com/finance/stocks/sncf-reseau/news/885927.html).
[24] https://www.autorite-transports.fr/wp-content/uploads/2018/01/bilan-ferroviaire-2015-2016-version-anglaise.pdf
[25] https://www.itf-oecd.org/sites/default/files/docs/high-speed-rail-competition-italy.pdf
[26] https://www.ilsole24ore.com/art/treni-ad-alta-velocita-18mila-ore-ritardo-2018-l-autorita-si-cambi--AFRcXjM

Figure 8.6: Italian Rail Transport Market



However, in some high passenger traffic corridors, HSR was able to fundamentally change the modal split in favour of rail. Evidence from the corridor Roma-Milano shows how the modal shares of air, car and train travel can be deeply influenced by the introduction of HSR. On such routes, air and rail travelling times are now very similar, and the transport modes can be considered as substitutes. From 2008 to 2014, the rail modal share significantly increased, from 36% to 65% (ART, 2015). Passenger on airplanes halved (from 50% to 24%) and travel by car was reduced from 14% to 11%.[27]

In terms of investment, they are on the higher end of the spectrum as the cost per kilometre ranges between €31m and €68m.[28]

8.1.6 Spain

Spain has the longest High-Speed rail network in Europe with over 3,200km of High-Speed railway lines. Despite this, it's ridership is only at 22m passengers per annum, less than quarter of that of the french TGV network.

Table 8.2 below demonstrates that High-Speed rail has been steadily encroaching on traditional rail (operated by RENFE). In 2006, less than 1% of passengers were travelling on the AVE network, while by 2019 this has increased to 4.4%.

[27] https://www.itf-oecd.org/sites/default/files/docs/high-speed-rail-competition-italy.pdf
[28] https://re.public.polimi.it/retrieve/handle/11311/1015984/186783/Beria%20Bel%20et%20al%20-%20Mismatches%20HSR%20Italy%20n%20Spain%20-%20PAPER%2013%20%5BSENT%5D.pdf

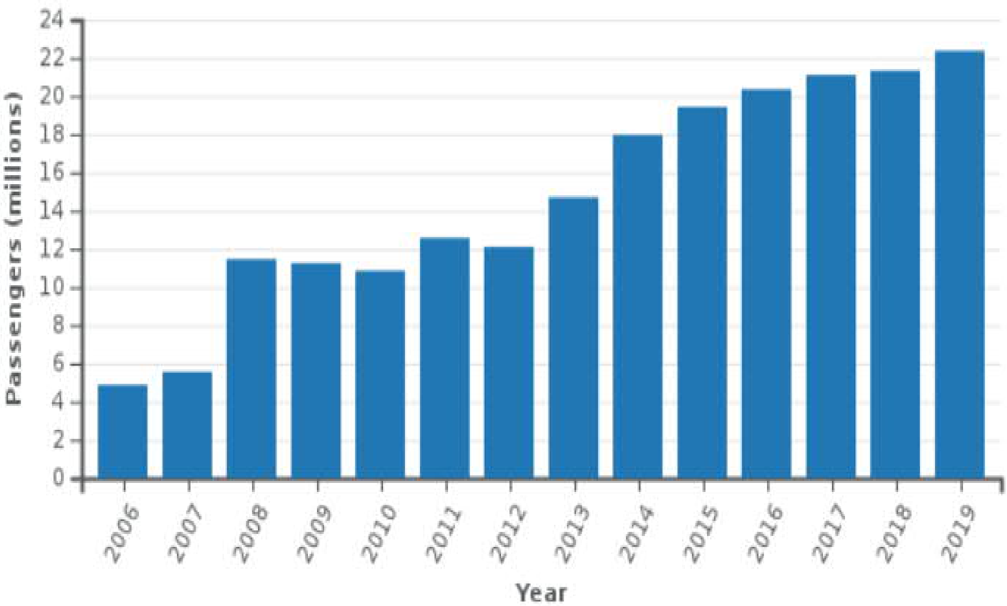
Table 8.2: High-Speed Traffic in Spain 2006-19[29]

Year	AVE passengers 000	RENFE Passengers 000	AVE Share %	AVE Passenger-km million	RENFE Passenger-km million	AVE share %
2006	4 878	527 975	0·92	1 884	20 480	9·2
2007	5 559	517 583	1·07	2 161	20 167	10·72
2008	11 461	510 176	2·25	4 888	22 281	23·09
2009	11 250	476 334	2·36	5 260	21 895	24·02
2010	10 851	463 012	2·34	5 171	21 166	24·43
2011	12 563	476 917	2·63	5 846	21 585	27·08
2012	12 101	472 145	2·56	5 793	21 319	27·17
2013	14 697	466 057	3·15	7 095	22 563	31·45
2014	17 967	464 961	3·86	8 038	23 754	33·84
2015	19 428	465 201	4·17	9 230	24 825	37·18
2016	20 352	471 359	4·32	9 632	25 291	38·08
2017	21 108	487 881	4·33	10 267	26 060	39·40
2018	21 332	507 088	4·21	10 289	26 931	38·21
2019	22 370	510 453	4·38	10 760	27 263	39·47

This is directly related to the average occupancy sitting at only 24.8% (as opposed to the 67% of the TVG).[30]

However, as for all High-Speed railways lines, demand has been steadily increasing since its inauguration as shown in Figure 8.2.

Figure 8.7: AVE annual Ridership (million Passengers)



[29] https://www.railwaygazette.com/in-depth/high-speed-open-access-comes-to-spain/56641.article?adredir=1
[30] https://www.railwaygazette.com/in-depth/high-speed-open-access-comes-to-spain/56641.article?adredir=1

On a number of lines, the introduction of High-Speed rail has drawn a significant amount of domestic air traffic to the AVE as seen below, particularly on the Madrid – Saville line as shown in Table 8.3

Table 8.3: Changes in Air/Rail Market Share as a Result of the Introduction of AVE

Corridor	Before AVE	With AVE	% Air market share lost to AVE
Madrid - Barcelona	88%	68%	23%
Madrid - Malaga	72%	38%	47%
Madrid - Valencia	58%	27%	53%
Madrid - Sevilla	79%	18%	77%

Source: Development of High-Speed Rail Services: the Spanish experience, RENFE

In terms of average cost per construction, it is difficult to draw conclusions as it varies greatly, from less than €3m per kilometer built to €54m for more technically challenging and more recent projects. [31]

8.2 Punctuality statistics

8.2.1 Punctuality in the corridor

Table 8.4 shows punctuality for long distance and regional trains in southern Sweden and freight trains. A train counts as punctual if it reaches its final destination within 5.9 minutes from schedule. Cancelled trains are not shown in Table 8.4. Currently, around 3% of trains are cancelled on the routes Stockholm to Gothenburg and Stockholm to Malmö/Copenhagen.

Table 8.4: Train Punctuality in Southern Sweden

	2017	2018	2019	Average 2008-2019	Average 2017-2019
Stockholm - Malmö/Copenhagen	65.8%	68.5%	75.3%	67.3%	69.8%
Stockholm - Gothenburg	74.3%	65.2%	78.2%	71.7%	72.6%
Stockholm - Karlstad/Oslo	80.5%	68.1%	72.9%	72.7%	73.9%
Freight Trains	80.8%	73.2%	77.9%	75.5%	77.3%
Gothenburg - Malmö	84.9%	82.2%	85.8%	84.9%	84.3%
Gothenburg - Oslo	91.7%	85.7%	90.7%	81.8%	89.4%
Gothenburg regional trains	93.6%	90.9%	93.9%	92.8%	92.8%
Malmö regional trains	93.8%	92.1%	94.3%	88.4%	93.4%
Stockholm regional trains	92.6%	92.1%	95.9%	93.5%	93.5%
Linköping/Norrköping regional trains	97.4%	96.7%	96.7%	88.8%	96.9%

Source: Trafikverket

As the table shows, punctuality on these lines has generally improved in recent years and is currently between 72.9% and 96.7%. It is important to note that punctuality on regional services is generally higher (92.9%) compared to long-distance journeys (76.1%).

Punctuality has been known to affect travel choices in Sweden. Domestic air travel has increased sharply after 2010 on the Stockholm-Malmo line, which suffered the lowest level of punctuality of

[31] https://www.railwaygazette.com/in-depth/high-speed-open-access-comes-to-spain/56641.article?adredir=1

train services that year (52%) and reduced in 2018 and 2019 following a marked improvement after the increase of train frequency in 2016.

Internationally, the correlation between High-Speed rail punctuality and HSR demand is not well documented. The comparison of these patterns in various countries does not provide a clear correlation.

8.2.2 Italy

In Italy, the average delay in 2018 was 7.4 minutes for arrivals and 2.4 minutes for departures, showing a steadily increasing trend in the preceding five years, attributed by the Italian Transport Authority to a rapid increase in passenger numbers causing the network to be saturated as well as the need for an innovative track assignment system. As the table below shows, that punctuality has been reducing in recent years from 72% to 61% in five years. However, this did not cause demand to reduce as shown in Table 8.5.

Table 8.5: Punctuality and Demand in Italy

Year	On time (within 5 min)	Billion passenger km
2014	72.0%	13.14
2015	68.3%	15.10
2016	66.6%	16.40
2017	67.4%	18.40
2018	61.1%	-

Source: High-Speed trains, 18 thousand hours of delay in 2018. Il Sole 24 Ore, 2019

8.2.3 France

The TGV in France performs at a similar level of punctuality in recent years. Punctuality and demand do follow a similar pattern, however, external factors may be more influential in the variation over the years, such as the strikes in 2018 and the roll-out of new services in 2019 causing a dip in demand in 2018 and a strong resurgence in 2019 as shown in Table 8.6.

Table 8.6: Punctuality and Demand in France

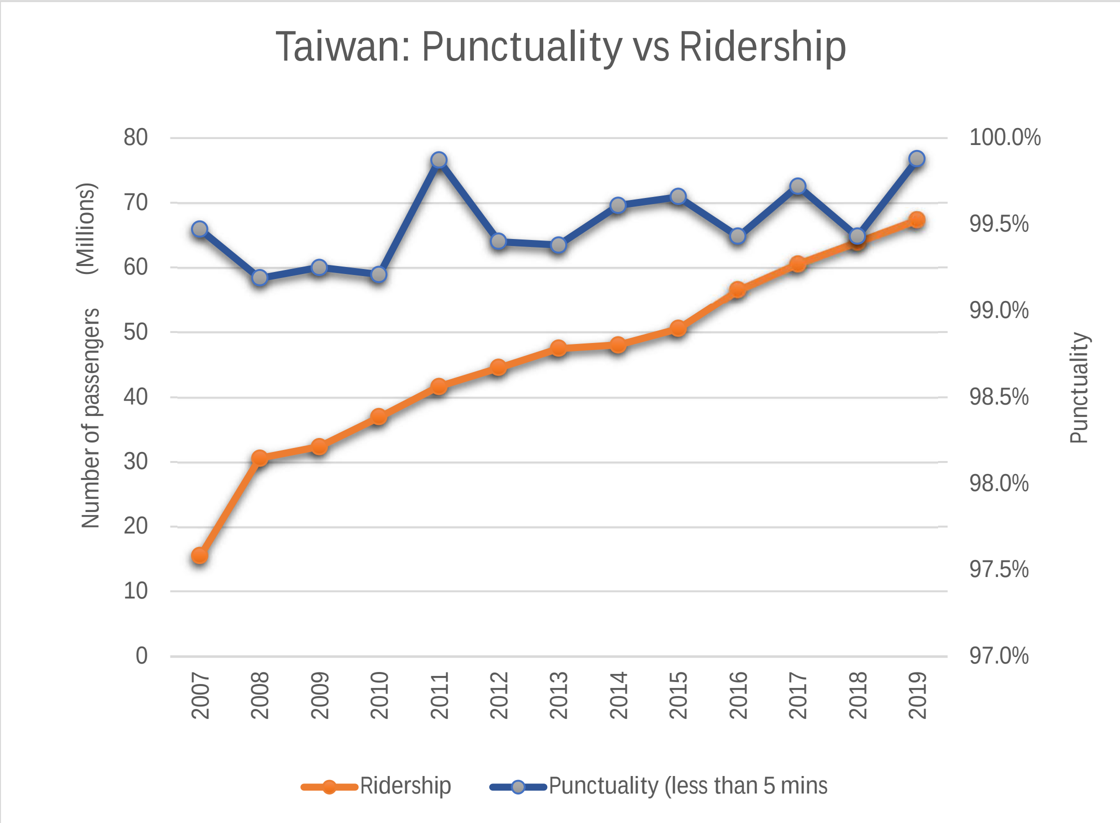
Year	Punctuality	Billion passenger km
2015	83.5%	55.2
2016	82.2%	54.8
2017	80.4%	59.6
2018	80.0%	58.6
2019	94.2%	66.2
2020	80.7%	-

Source: Official punctuality data TGV, SNCF

8.2.4 Taiwan

Similarly, Taiwanese High-Speed rail demand and punctuality data does not suggest a clear correlation as shown in Figure 8.8. However, it is likely that the level of punctuality has been high enough over the years that its effects are not strongly felt by the users. Punctuality varies between 99% and 100% while demand has grown steadily since 2008 at a rate of 7.5%.

Figure 8.8: Punctuality vs Ridership in Taiwan



8.3 Corridor comparisons

Results from our data collection of international corridor comparisons are shown below. Table 8.7 shows demand levels for some key city pairs in the context of travel distance and population size.

Table 8.7: International High-Speed Rail Corridors

City Pair	Population in Metro Areas (m)	Distance (kms)	Annual Demand (million trips)					Data year	Source
			Rail	of which HSR	Air	Car	total		
Stockholm-Gothenburg	2.8/1.4	466	4.9	4.9[32]	1.3	5.1	11.6	2040 Forecast	1
Stockholm-Malmö	2.8/1.2	613	2.1	2.1[32]	1.4	2.3	6.1	2040 Forecast	
Munich-Berlin	2.5/5.1	632	3.4		2.0			2018	2
London-Paris	12/10	350	4.2	4.2	2.0		6.1	2004	3
London-Paris	12/10	350	11.0	11.0				2018	4
Tokyo-Osaka	37/19	553	105	105	9			2017	5
Madrid-Barcelona	6.5/5.3	621	0.8	0	5		5.8	2007[33]	
Madrid-Barcelona	6.5/5.3	621	3.1	3.1				2013	6
Madrid-Seville	6.5/1.5	472	2.1	2.1				2012	
Madrid-Valencia	6.5/2.0	350	1.9	1.9				2013	
Madrid-Malaga	6.5/1.1	520	1.3	1.3				2013	
Madrid-Zaragoza	6.5/0.8	320	1.2	1.2				2012	
Madrid-Valladolid	6.5/0.4	190	1.2	1.2				2013	

Sources:

1 Sampers 2040 HSR Reference Scenario (re-based)

2 http://www.xinhuanet.com/english/2018-06/15/c_137256855.htm

3 Intermodal Competition in The London-Paris Passenger Market: High-Speed Rail and Air Transport Christiaan Behrens Eric Pels

4 https://www.theguardian.com/business/2019/oct/17/eurostar-enjoys-busiest-august-as-passengers-seek-alternative-to-flying

5 https://www.railway-technology.com/features/faster-flying-high-speed-rail-routes-taking-air-industry/

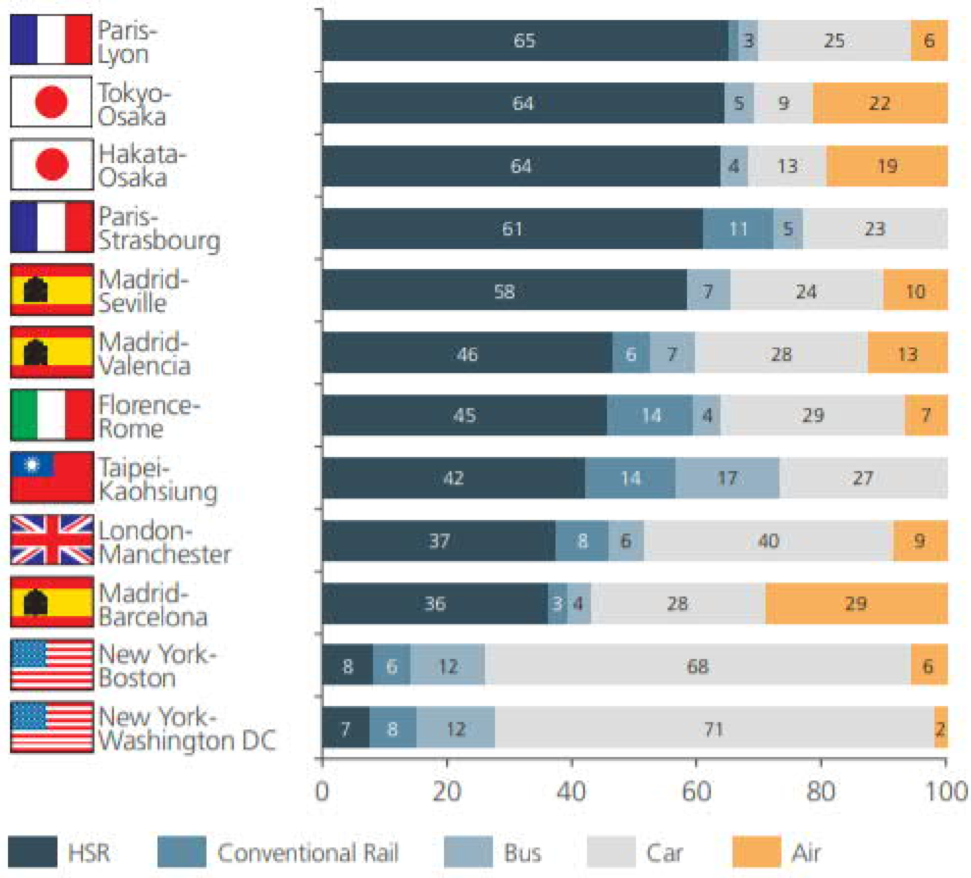
6 Beria, P et al (2016), Delusions of success: costs and demand of high speed rail in Italy and Spain

Figure 8.9 shows international comparison of modal share in some key High-Speed rail corridors.

[32] Assuming all long-distance rail demand between these city pairs will be carried by high-speed rail in the future

[33] Pre-HSR

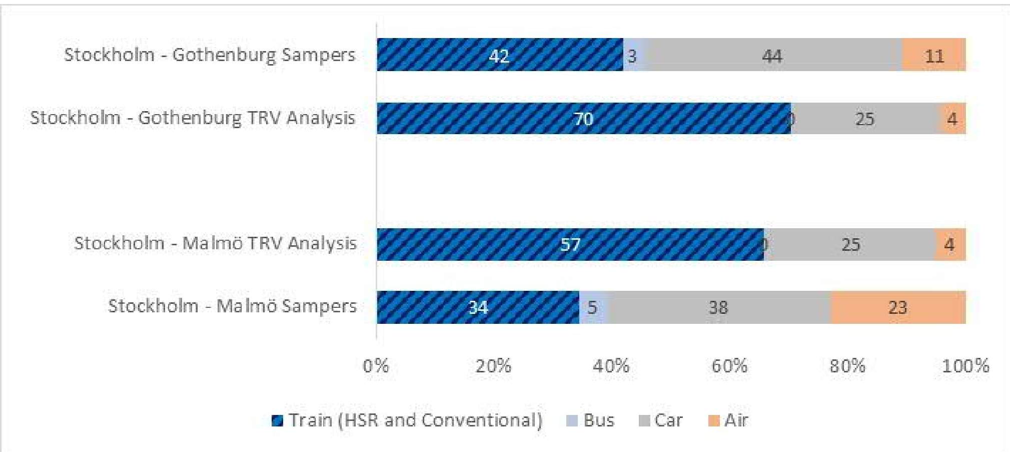
Figure 8.9: Modal Share on selected High-Speed Rail Routes (2018)[34]



Source: L.E.K. Consulting / Executive Insights, Volume XXI, Issue 9

This may be compared against the 2040 forecast mode shares from Sampers and the TRV analysis for the two Swedish corridors as shown in Figure 8.10.

Figure 8.10: Predicted Mode Shares for the Swedish High-Speed Rail Corridors



This indicates that the rail mode shares for the two corridors from Sampers lie well within the range found in international comparison, while the numbers from the TRV analysis tend to be at the higher end.

[34] We note that the 2018 annual report for the Central Japan Railway Company quotes different shares of Tokyo-Osaka 85% rail and 15% air which implies a higher rail share than is shown in the LEK data.

9. Overall View on the Forecasts

9.1 Stockholm to Gothenburg

Our review of available data suggests that all the projections used for demand growth from base to forecast year appear cautious when compared with expected GDP growth which is generally seen as the main driver for travel demand. This is particularly the case for the PwC forecasts.

In the Sampers-based forecasts, 59% of all growth is catered for by Car, with 32% by rail with the rest distributed between air and bus. Rail gains some share at the expense of air over the forecasting period, with the rail share of the combined rail/air market increasing from 62% in 2017 to 68% in 2040. This is the result of very low growth in air demand over the forecasting period which is consistent with recent trends that have seen a decline in domestic air demand.

Once a future year no-HSR position is established, Sampers predicts a relatively high level of generated demand as a result of the implementation of High-Speed rail but low levels of abstraction from other modes. Both PwC forecast and TRV analysis projection assumes higher abstraction from air and car modes.

Projections for High-Speed rail demand range from 4.9m (Sampers) to 6.4m (TRV analysis). Our own indicative calculation using an elasticity-based approach returns projections in the range of 5.9m to 7.4m.

Taking the available evidence in the round, we would therefore regard the Sampers-based forecasts as conservative, though we note that a wide range of outcomes is shown in international comparison.

9.2 Stockholm to Malmö

The commentary above on demand growth from the base year apply to this corridor too. Here the PwC forecast is less pessimistic, but all forecasts lie significantly below the expected GDP growth.

Sampers predicts a similar proportion of generated demand in this corridor and low abstraction from other modes, with larger proportions suggested by both PwC forecast and TRV analysis. In this corridor, the PwC forecast for HSR demand is very similar to Sampers while the TRV analysis projection is again higher than both.

In this corridor, in the Sampers-based forecasts, 56% of the growth is catered for by car with 28% attributed to rail. Again, rail gains some share from air over the forecasting period with the rail share of the combined rail/air market increasing from 38% in 2017 to 47% in 2040.

Projections for High-Speed rail demand range from 2.1m (Sampers and PwC forecast) to 2.9m (TRV analysis). Our own indicative calculation using an elasticity-based approach returns projections in the range of 3.4m to 5.2m, with even our lower estimate higher than that from other sources. We would therefore regard the Sampers-based forecasts as very conservative, though again we note the wide range of outcomes shown in international comparison.

9.3 Stockholm to Copenhagen

It is clear from this review that travel to Copenhagen is not adequately represented in the Sampers projections and an alternative forecasting method is required. More realistic forecasts are available both from PwC forecast and TRV analysis with projections of 1.0m and 1.3m annual trips respectively. We have sought to add to this analysis by estimating and “envelope” of plausible forecasts for High-Speed rail demand between Stockholm and Copenhagen.

As has been shown in Table 6.35, the PDFH approach would project between 1.4m and 3.0m annual trips. However, this is based on formulae and parameters that were derived for domestic travel in the UK which take no account of the “border effect” of travel to a different country.

We have also used the indicative gravity model described in section 7.5 to provide an alternative forecast. Again, this ignores a border effect and is based purely on:

- Rail journey times;
- Train frequencies; and
- Relative population sizes.

Such a model, calibrated to reproduce similar demand levels to Sampers for Stockholm-Gothenburg and Stockholm-Malmö, would predict around 2.9m annual rail trips from Stockholm to Copenhagen.

International evidence on the “border” effect is difficult to find. While there are some busy international High-Speed rail routes, most international rail travel is dominated by relatively local commuting movements. In fact, the local rail service between Malmö and Copenhagen is probably the most frequent international rail service in the world. Significant international commuter movements are also found, for example between Basel (Switzerland), St Louis (France) and Lörrach (Germany), or between France and Luxembourg.

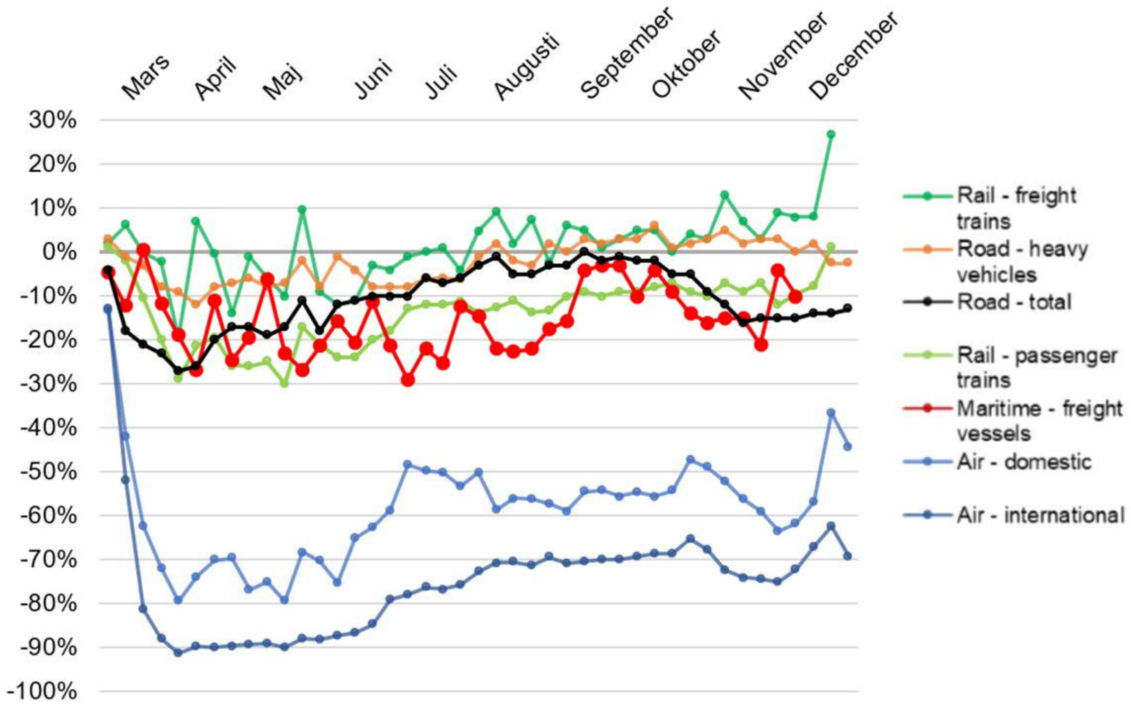
Available data on longer distance routes suggests four times the rail demand level between Paris and Lyon (44m) compared with Paris to London (11m) despite the much larger population size of London compared with Lyon. However, the Paris-Lyon figure includes all trips on the route, covering intermediate stations and destinations beyond Paris or Lyon. Similarly, in Ireland, rail demand between Dublin and Cork (3.7m) is 3.7 times the demand between Dublin and Belfast (1.0m) despite the larger population size of Belfast compared with Cork. This indicates that the “border effect” is quite significant, suggesting that the lower end of the envelope of forecasts of around 1.4m passengers for Stockholm to Copenhagen is more realistic with a further 0.5m passengers from intermediate stations (excluding Malmö) to Copenhagen. However, higher demand levels could be expected if the economic and cultural connections between Sweden and Denmark are stronger than those between the UK and France or between Northern Ireland and the Republic of Ireland.

It should be noted that while higher demand levels to Copenhagen may strengthen the overall case for the project, the benefits accruing to travellers from Sweden to Kastrup Airport and to Copenhagen may need to be treated differently in project appraisal from those accruing to Swedish domestic travellers.

9.4 High level commentary on COVID-19 impact

The land use and economic input parameters to the forecasts reviewed here are based on pre-pandemic projections. While it is clear that the COVID-19 pandemic has a profound impact on the travel demand by all modes in 2020 in Sweden and worldwide, it is not yet clear how it will affect longer term trends. Figure 9.1 shows the development of demand for travel by different modes since the start of the time the pandemic took hold in Europe and most countries went into various forms of lockdown or imposed travel restrictions, compared with the corresponding period in 2019.

Figure 9.1: Weekly Traffic by Mode in 2020 compared with the corresponding Week 2019



Source: Transport Analysis (Trafa)

This shows profound effects on air travel, with domestic travel some 50% below 2019 levels by the autumn of 2020 when some restrictions had been lifted and international travel down by over 60%. rail and road passenger travel had initially declined by up to 30% and while road traffic had recovered to within 5% of 2019 levels by the autumn, rail travel was still significantly lower than in 2019. It should be noted that the reduction in rail of some 10% compared with 2019 is based on trains which masks a much larger reduction in passenger numbers.

What is shown here are the net effects which include shifts between modes. For example, the relatively modest decline road demand may in part be due to a shift of demand from aviation and rail. It is possible that road demand has recovered more quickly as people seek the isolation of their own car when travelling and the combination of COVID impacts and a heightened awareness of climate change issues may mean that aviation demand will never return to pre-pandemic levels. Future travel behaviour will be affected by a combination of –

- Personal concerns;
- Government policy;
- Changes in personal economic circumstances;
- National or global economic changes; and
- Personal behaviour change.

The likely long-term impacts of the pandemic can only be understood through scenario testing at the moment and our recommendation is that such scenarios should be run through Sampers to examine the potential range of outcomes. Such scenarios should be developed through discussion and consultation with key stakeholders and should consider some of the factors listed in Table 9.1.

Table 9.1: Influencing Factors for post-Covid Behaviour Change

Pre-Pandemic Habits	Possible drivers of personal behaviour change	Possible influencing factors
Travel to work, dominated by public transport (cities) and car (outside cities)	▪ Long term trend towards more remote working ▪ Possible modal shifts	▪ Higher levels of unemployment ▪ Road space re-allocation ▪ Reductions in public transport capacity ▪ Land use changes
Travel to meetings, both short and long distance	▪ Possible reduction of face-to-face meetings	▪ Better availability and quality of online meeting facilities ▪ More cost-conscious corporate travel policies
Visits to bars and restaurants	▪ Desire to return to normal	▪ Permanent closure of some bars and restaurants
Visits to friends and families	▪ Desire to return to normal	
Visits to theatres and museums	▪ Desire to return to normal	▪ Permanent closure of some theatres or museums
High Street shopping	▪ Lasting reduction due to new habits	▪ Increased availability of online shopping facilities ▪ Closure of high street shops
Big summer holiday by air	▪ Increased environmental awareness	▪ Reduced airline capacity ▪ Increased environmental taxes
Weekend trips away by air	▪ As above	▪ As above

In the longer term, some changes in behaviour, together with re-enforcing external factors, could be quite profound:

- Land use: It is possible that the current travel restrictions lead to a new wave of decentralisation, with different land use patterns and lower densities of development over time. This may be re-enforced by the travel choices people make, with a shift to shorter, local journeys by car or bicycle.
- Propensity to travel: We have already seen some reductions in household trip rates in most developed countries over the last few years. This trend may be accelerated.
- Trip Distribution: Any longer-term changes to population patterns will have a profound impact on trip distribution.
- Economic factors: Longer term GDP growth may be impacted significantly by the pandemic.

The resulting scenario tests may include a range along the following lines:

- A high scenario, where economic activity and behaviour rebounds relatively quickly, recovering its pre-virus levels of travel demand at some point during 2021 and there is no enduring impact on either the economy or travel behaviour. In effect this is represented by the current set of forecasts.
- A central scenario, where economic output regains its pre-virus level by the end of 2023. There is no enduring impact on travel behaviour and forecasts can be adjusted by modifying the economic input parameters.

- A low scenario, where economic output recovers more slowly, returning to its pre-virus peak by the end of 2025. This results in a more significant loss of business investment, more firm failures and persistently high unemployment as the economy undergoes significant restructuring. Trip making is reduces as a result of lower GDP levels. In addition, trip rates are reduced for all journey purposes as people work more from home, travel to fewer business meetings and undertake more online shopping.

These changes in behaviour are likely to have a more significant impact on shorter trips but will also affect the demand for long distance travel. For example, the possibility of homeworking may accelerate a trend for people to move out of larger conurbations in search for more affordable or higher quality housing. They may then commute over a longer distance once, twice or three times a week instead of undertaking a local commuting journey every day.

Appendix A. Bibliography

A.1 Material made available by Trafikverket for this review

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- A range of high level tables, graphs and diagrams provided in emails as shown in this report

A.2 Other material consulted in this review

- Two spreadsheets containing outputs from the National Transport Model Sampers for a 2040 Base scenario:
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