MODELLING CHANGES IN REGIONAL ACCESSIBILITY FROM SPEED LIMIT ADJUSTMENTS IN THE ROAD NETWORK

Jonas Westin, Umeå University
Johanna Knutsson, CERUM, Umeå University
Lars Westin, Umeå University

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Preface

The European road TEN-T E12 from Helsinki in Finland, to Mo I Rana in Norway, is the central passage through the Botnia-Atlantica region. The project “E12 Atlantica BA³NET” (in short BA³NET or BA²NET) analyses decision making with regard to transport policy in cases related to cross border infrastructure, in the Botnia-Atlantica region, as well as more generally. The findings thus is of importance for the region but also for actors in each of the Nordic countries, actors at the Nordic level, as well as for decision makers within the European Union.

The project has been financed by INTERREG Botnia-Atlantica, Kvarkenrådet, Trafikverket i Sverige, Statens vegvesen and Jernbanedirektoratet i Norge, Förreningen Blå vägen, MidtSkandia, Nordland fylkeskommune, Österbottens Förbund and the city of Vasa. Nord, Umeå, and Vasa universities have made their facilities available to the project. We are deeply thankful for this support.

The project is an example of Nordic research collaboration within the Botnia-Atlantica region. The three authors of this report are from CERUM at Umeå University in Sweden. The group of researchers also includes Professor Petri Helo at Vasa University in Finland, Professor Gisle Solvoll and Associate Professor Thor-Eric Sandberg Hanssen, both at Nord University in Norway. Comments, suggestions, and stimulating discussions within this group are hereby acknowledged.

We are also grateful to inputs to the project from among others Gunnar Isacsson Trafikverket, Mats Bengtén Trafikverket Region Nord, Tor Nicolaisen Jernbanedirektoratet, Oskar Andreas Kleven Statens vegvesen, Taneli Antikainen Väylä, Andreas Forsgren Umeå kommun, Mathias Lindström Kvarkenrådet, Tero Voldi Österbottens förbund, Mårten Edberg Region Västerbotten and Anders Östergård NMT-centralen in Finland. Each has been part of the reference group to BA³NET.

In the report, the mutual dependencies between accessibility and speed limits on a road of a given quality is studied. For a given road, a reduced speed limit would reduce accessibility to different activities and facilities. A motive for reduced speed limits may be an increased valuation of the cost of accidents and foregone life. If the traffic flow on the road not motivates measures to increase the safety properties of the road, a reduced speed limit may be the remaining alternative.

Dependent on where in the road network the transport administration changes speed limits, the impact on the accessibility for a population will vary. A method is in the report developed to identify the geographical distribution of those affected. This may be an input to decisions where in the network changes is possible without major impacts on accessibility and where major changes in accessibility will be the outcome.

Hence, the report is an important contribution and in line with the aim of BA³NET to increase knowledge regarding cross border transport planning, decision making among actors within the Botnia-Atlantica region, and the impact of various measures taken. In this respect, the project BA³NET has been working closely together with the INTERREG Botnia-Atlantica project “E12 Atlantica Transport”.

Umeå, November 12, 2019

Jeanette Kjellberg
Project leader BA³NET
Abstract

The Swedish Transport Administration will adjust the speed limits in the Swedish road network. A point of departure for this adjustment is Vision Zero, a traffic safety project approved by the Swedish Parliament in 1997. The goal of Vision Zero is a radical reduction of the number of fatalities or serious injuries on Swedish roads. However, the suggested new speed limits have given rise to debate and criticism. Regional and local actors have argued that a reduced speed limit may have negative impacts on accessibility and local development. The road network in the Botnia-Atlantica region contains roads where the Transport Administration has suggested reduced speed limits. Sections of the TEN-T E12 road and connecting nearby roads are parts of those roads. The illustrative cases chosen are a part of the E12-region around the city Umeå in Sweden. The purpose of the paper is to present a method for analysis of the distribution of changed accessibility over places, in response to changed speed limit in the road network. The suggested method should be a basis for a dialogue on accessibility and security between local and regional actors on one hand and the Swedish Transport administration on the other. Accessibility although is a multifaceted phenomenon. The impact of changed accessibility on an economy both contains general elements as well as elements of very situation specific character. Given this, the modelling approach suggested make use of three different model approaches; EVA, SAMPERS and PIPOS. The comparison of outcomes from the three models gives an in-depth picture of how changes in speed limits affect accessibility and regional development.
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Introduction

Currently, the Swedish Transport Administration are working on a comprehensive review of speed limits in the Swedish national road network. The aim is to improve the match between official speed limits, road standards, and road safety. One motive for those adjustments is the road safety project “Vision Zero”, a bill passed by the Swedish Parliament in 1997 with the long-term goal to decrease severe injury and fatalities within the road transport system (Johansson, 2009). Since most adjustments in the program will imply a reduced speed limit, the adjustment process has given rise to a critique from municipalities, actors and individuals that may be affected by those reduced speed limits.

Consequently, administrative courts in Sweden have repealed decisions by the administration to change limits with the motivation that the Transport administration not have investigated the consequences of a reduced speed limit sufficiently. Given this, if the Transport Administration wants to continue the process, the Administration is in need for better analytical methods to investigate regional and local consequences of reduced speed limits in the road network. Apparently, municipalities may also use such methods to prove their case. The hope is that such a dialogue may result in speed limits, road standards, and measures taken in order to create a road network that fulfils both the concerns of the Transport administration as well as the social efficiency requirements set by the national parliament.

Given this, the purpose of this paper is to present a methodology for the identification of the spatial (geographical) pattern of changed accessibility due to speed limit adjustments in a road network. Hence, the project will produce a first basis for further investigations of the possibly broader regional economic consequences the ambitions of the Swedish Transport Administration to adjust speed limits will have on places.

Figure 1. The Botnia-Atlantica region to the left. Source: botnia-atlantica.eu. The transport system around the TEN-T E12 region to the right. Source: Kvarkenrådet (2018).

The cases presented here are from the TEN-T E12-region. The TEN – T E12 region is shown in Figure 1. The letter E in the shortening reflects that the E12 road is part of the European road network as defined by UNECE, United Nations Economic Commission for Europe. However, E12
is also a TEN-T road. TEN-T is short for the Trans-European Transport Network, a network for communication decided by the European Union. The TEN-T E12 region and its main communication link, the TEN-T E12 road, thus connects the Botnia-Atlantica region internally and motivates its existence as a regional identity. The Botnia-Atlantica region is a cross-border international region and, as Figure 1 shows, covers regions in Norway, Sweden, and Finland.

The paper has the following outline. In the next section, we give a background to the problem of choosing speed limits while taking care of concern for road safety as well as accessibility on roads of given standard. Thereafter, a section follows that presents the properties of the road networks in the TEN-T E12 region and the broader Botnia-Atlantica region. This is followed by a presentation of three models for assessment of impacts of speed limit adjustments, after which our results are presented. A discussion of our findings rounds off the paper.

Traffic Safety, Accessibility and Speed limits – a Background

Traffic safety in the road network - Vision Zero

The driving force behind the suggested adjustment of speed limits in the road network is the ambition by the Swedish Transport Administration and the Swedish Parliament to improve traffic safety. The increase in the number of traffic related fatalities in 2018 induced a political pressure on the Transport Administration to take measures in order to increase traffic safety and reduce the number of killed and seriously injured on roads.

Already in 1994, traffic safety was by the Swedish Traffic Administration declared as top priority. This introduced a new paradigm in Swedish transport policy. The safety paradigm was by the Administration given the name “Vision Zero”. As such, it not only focused on the development of new strategies in order to reduce the fatality risks in road traffic, but also introduced a new ethical approach to injuries and fatalities in road transport policy. The Swedish Parliament passed vision Zero as a bill in 1997. It then became a long-term goal that has altered the aim of all measures concerning road traffic safety; from what could be done to reduce the number of accidents, to what must be done ‘to eliminate the risk of chronic health impairment caused by a traffic accident’ (Johansson, 2009). Instead of a focus on prevention of accidents, the new goal became that no person should die or be seriously injured in the traffic on roads.

One part of “Vision Zero” is to design a safe traffic system that manages kinetic energy in collisions etc. While road design, such as physical separation of lanes and of the road network from surrounding areas, was one aspect of this work, another aspect of “Vision Zero” was a general reduction of the speed of vehicles on the road network.

In 2016, there was a renewed commitment to “Vision Zero” by the Swedish government. The Swedish Transport Administration should propose new intermediate road safety targets using road design and reduction of speed limits in built-up areas (Government Offices of Sweden,
2016). The normative basis for “Vision Zero” can be view as different from the normative principles used in ordinary cost-benefit calculations for investments and other measures in the road network used by the Swedish Transport Administration.

In cost-benefit analysis, the benefit of traffic safety is in the calculations weighed against other benefits such as accessibility. Benefits of traffic safety is in cost-benefit analysis estimated as a set of parameters such as value of life, to be included in a generalized transport demand function. In this respect, “Vision Zero” may be interpreted as that the Swedish Parliament has imposed such a high value on life and safety in the cost-benefit calculations that it substantially increases the benefit of measures that reduce the risk for serious accidents to zero. On the other hand, in the daily cost-benefit calculations performed by the Transport Administration of measures suggested to be implemented in the road network, the old values obtained from various empirical studies, still are applied. Hence, both the Swedish Parliament and the Swedish Transport Administration have two set of goals and two set of valuations the govern their ambition to obtain a socially efficient transport network for Sweden.

Accessibility in the road network

Traffic safety and “Vision Zero” is of cause not the only political goal for the transport system in Sweden. If it would, speed limit reductions would not be controversial. Travel and transportation are necessary parts of a society in order for it to exchange, specialize, and develop. The goal for the transport system is to ensure “the provision of economically efficient, sustainable transport services for the general public and businesses throughout the country” (Government Offices of Sweden, 2019). The traditional part of this objective is to increase accessibility for citizens and businesses alike, as well as to create accessibility within and between regions. People should be able to live where they please and still have access to a labour market region (Prop. 2008/09:93).

Increase of accessibility thus is a general argument used to motivate reduction of travel time between destinations. For a long time, higher speed in the road transport system has been a goal for the Swedish and international transport policies. In this respect, transportation systems are physical measures to strengthening basic functions between areas in space, connecting people, markets and resources (Gould, 1969). Sweden is a large sparsely populated country, the maintenance of an efficient road network thus is important for mobility and accessibility. Accessibility is one important factor that will have an impact on regional development and quality of life (Sreelekha et al., 2016).

However, accessibility may and have been defined and measured in many ways. Its impact on regional development is neither simple nor straightforward. Accessibility has been measured by geographical distance, by travel time, or by generalized transport costs between places, facilities, and locations. Accessibility can also be extended to measure accessibility to a potential, such as the possibility to reach other locations and their supply or demand. Then accessibility have been measured by gravity-based approaches, localization potentials, or log-sums.

Assumed positive effects on regional development have been frequent political arguments in
order to spend resources on investments and other measures with the aim to improve accessibility and reduce travel time. The argument then has been that reduced travel time will strengthen a local economy by facilitating long distance commuting and enlarging a local labor market. However, the possibility to commute has its limits and differ between individuals based on their location, family constellation, education, assets, age, and gender. As is well known, the willingness to commute is drastically reduced when travel time exceeds 40-45 minutes. A reduced speed limit thus narrows labor markets and makes the ambition that “people should be able to live where they please and still have access to a labor market region” more difficult to fulfil.

Impacts of speed limit adjustments on regions

Hence, speed regulations are a contested issue in Sweden due to opposing opinions between planners, politicians and actors that have either a dominant road safety or mobility perspective (see Table 1). Increased speed is an argument for increased accessibility and regional development by some, which put individual commuting propensities within a labor market in focus, while reduced speed limits are a crucial component for other politicians and planners, which favour traffic safety (Svensson et al., 2014).

<table>
<thead>
<tr>
<th>Goals</th>
<th>The mobility perspective</th>
<th>The road safety perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means</td>
<td>Economic growth</td>
<td>Road safety</td>
</tr>
<tr>
<td></td>
<td>Mobility and high speed</td>
<td>Low speed</td>
</tr>
</tbody>
</table>

Table 1. Overview of local and regional actors' perspective on speed limits. (Svensson et al., 2014).

Since the introduction of “Vision Zero”, the vision has had a growing influence on the willingness to reduce road speed limits. For instance, between the years 2008 – 2009, most speed adjustments on existing roads in Sweden were speed reductions. However, according
to Vadeby and Forsman (2018), due to their importance for communication and a relatively high standard, some roads of importance for local economies anyhow were given higher speed limits.

The study by Vadeby and Forsman (2018) confirms the general trend that the mean travel speed in Sweden has been reduced. On average, a 10 km/h decrease in speed limit led to a decrease in mean speed of between 2-3 km/h. Over time, the decrease of the signposted speed in Sweden has resulted in a subsequent reduction of fatalities in the road transport system.

However, the real safety effects of a speed adjustment to a large degree depends on the conditions and standard of the individual road. Most of the fatality reductions were on “rural roads” following a decrease from 90 to 80 km/h, while increasing the speed to 120 km/h on motorways was found to have little or no effect on the number of fatalities, although the number of severely injured increased. However, according to Vadeby and Forsman (2018), other actions taken, such as improved roads, changing driving patterns and safer vehicles could, also explain the reduced number of fatalities.

Limiting the maximum speed has a safety benefit not only because it reduces the kinetic energy in a potential crash, but also because it increases reaction time and breaking distance. However, while it is estimated that 85 per cent of drivers on a road will comply with the legal speed limit, speeding is common and a large part of fatalities could according to Elvik (2012) be reduced if speeding was eliminated. The adjustment of speed limits with a safety perspective may according to Elliott, Armitage and Baughan (2003) be seen as a behavior control with the aim to change the behavior of those who speed and has positive association with this behavioral intention. There are of cause also other options to pursue to compliment speed reductions, such as traffic cameras, police officers monitoring the actual speed to convince people to follow the law. Mandating ignition interlocks in cars are a further way to eliminate accidents caused by a combination of drugs and speeding.

As discussed, the mobility perspective is the other aspect when speed limits are chosen. In this perspective, the focus is on accessibility, commuting, and value creation. Increased speed limits give people opportunities to commute longer distances in the same amount of time, which contribute to the enlargement of their labor market regions. Increased accessibility thus often is considered as a way to support regional development.

However, from a regional science perspective, the link between accessibility and regional development is not so straightforward. Instead, it is complex and ambiguous. Vickerman, Spiekermann and Wegener (1999) argue that accessibility can have different effects on various geographical scales and is dependent on how it is measured. At a national scale, accessibility can be an important factor for a country with a flexible currency or wage setting regime, competing on the international market. However, typically the benefits from international trade is not distributed evenly among people and across regions. As observed by Banister and Berechman (2001), on a regional level, there also often is a redistribution effect on employment following accessibility investments. Traditionally, increased accessibility as well has been considered to have a concentrating effect on economic activity (Marshall, 1890;
Krugman, 1991). The impact can also be different between urban and rural areas (Rokicki and Stępniak, 2018).

Banister and Berechman (2001) give an empirical example. Using Spanish data from 1980 – 2007, the authors found that spillover effects of transport infrastructure investments indicated that results were asymmetric, and low-income regions benefited less from those investments. Álvarez-Ayuso et al. (2016) has thus argued that poor regions lose economic activity in favour of wealthier regions based on agglomeration economies. The impact of an adjusted limit or a road investment also depends on whether the affected road is mainly used for intra-regional or inter-regional transport (Chiambaretto, De Palma and Proost, 2013).

Hence, speed adjustments and changed accessibility will not alone have an impact on economic growth. Instead, many factors simultaneously have to act together with e.g. infrastructure investments to incite economic growth (Banister and Berechman, 2001).

From a regional economic perspective, changed accessibility changes absolute regional advantage and thus the relative competitiveness between regions and locations. The impact on economic development in a specific region therefore ultimately depends on how the region internally handles changes in its competitive environment. Increased accessibility can lead to increased economic activity in some regions, while activities in other regions are set under pressure. If increased accessibility comes with a cost of reduced life quality and fatalities, human capital in the region and thus its future production possibilities are reduced. The regional economic effect of increased or reduced accessibility can therefore go in both directions.

Of course, the solution of this conflict between safety and speed would be to take measures in order to improve roads such that both safety and speed may be increased. Median barriers that separate opposing traffic lanes or motorways are two alternatives to reach the combined goal of safety and speed. However, in order for those not to introduce barriers for both humans and wild life that may reduce the overall benefits of a chosen solution, they have to be combined with frequent tunnels and bridges as well as separate lanes for pedestrians, cyclists, and slower vehicles. Hence, the cost of such measures may only be motivated if substantial benefits may be expected. Benefits from the traffic or from other processes in the economy of a region. On not so highly trafficked roads, such as often may be found in rural areas, benefits is not always so high that it is possible to motivate such measures to be taken from a social efficiency and economic point of view.

Adding to the complexity of the problem is the fact that the marginal impact of a changed speed limit on a road segment may be very dependent on the design of each segment. Due to the complexity of the causalities involved in the safety, accessibility, regional development problem, it is often advantageous to study effects using an approach where results from different measures of accessibility and multiple models to evaluate impacts are analyzed and compared.
The road network of TEN-T E12 and the Botnia-Atlantica region

The distribution of population over the Botnia-Atlantica region is as may be seen in Figure 2 uneven. Along the TEN-T E12 road, the activities and populations around the cities Vasa, Umeå, Lycksele, and Mo i Rana are the major generators of passenger traffic flows.

Figure 2. Density of night population. Inhabitants per km². Darker blue areas represent higher density. Source: Kvarkenrådet (2017).

Those areas also generate flows of freight from retail and some industry. The industries within mining and forest are more outspread in the region. They generate the largest flows measured in tons and often use rail. There is a tendency to move especially transport of timber from the road over to rail.

Figure 3. Functionally prioritized road network to the left and the width of road segments along TEN-T E12 road and connected roads. Source: Kvarkenrådet (2017).
As seen in Figure 3, the TEN-T E12 road, a red line, is part of the by the Swedish Transport Administration functionally prioritized road network and considered as a nationally and internationally important road.

On the other hand, the standard of the road, measured as the width of each road segment, is in comparison with standard of the E4 road along the coast of Sweden rather low. Generally, near central Umeå and in the Umeå region, the road width is nine meters but further to the west it very frequently it is less than seven meters. This is also the case on the Norwegian side. In Finland, the road has a higher overall standard.

From the point of view of this study the speed limits on the road is important. As seen in Figure 4, the speed limit is 90 km/h for most of the road segments from Umeå to Lycksele, with some segments were limits are reduced to 70 km/h. This is also the case from Storuman to Mo i Rana in Norway. The road segment between Lycksele and Storuman instead have segments with nine meter width and speed limits in-between 90 and 120 km/h.

Figure 4. Speed limits on the TEN-T E12 road and surrounding road system.
Source: Kvarkenrådet (2017)

Given our discussion previously, there is a cost and benefit relation between speed and speed limit, traffic flow and road standard. According to the Transport Administration, a road should have median barriers with separated opposing traffic lanes and secure roadsides in order to have a safety standard that allow for a speed limit of 100 km/h. Some motorways with less
intensive traffic, e.g. not so near built up areas, may have a speed limit of 120 km/h. In order to be motivated by social efficiency, investments in median barriers seems thus to need an annual average daily traffic (AADT) of at least 4 000 to 6 000 vehicles. Roads with less than 4 000 but at least 2 000 AADT may have a speed limit of 90 km/h if there is a rifled middle line, and specific overtaking lanes. Other roads should have 80 km/h or 70 km/h if the traffic situation is characterized by high risks.

Figure 5. Annual average daily traffic (AADT) on the TEN-T E12 road and surrounding road system. Source: Kvarkenrådet (2017).

Figure 5 show AADT values for major roads in the Botnia-Atlantica region, including the TEN-T E12 road and the surrounding region. Major parts of the TEN-T E12 road has an average flow of less than 2 000 vehicles. This would indicate that the Transport Administration would reduce speed limits to 80 km/h on substantial parts of the road segments. On some segments, e.g. in between Lycksele and Storuman, the road quality may motivate 90 km/h.

In a previous study by Kvarkenrådet (2017) the reduced associability on the road network from a starting point in Storuman is shown. The two maps in Figure 6 indicate that changes will especially be noticeable in the direction to the east, along the TEN-T E12 road towards Lycksele and Umeå at the coast.
Figure 6. Accessibility, measured as travel time on the road network, from the center of Storuman at the TEN-T E12 road. To the left with a maximum speed limit of 80 km/h and to the right with a speed limit of 100 km/h. Source: Kvarkenrådet (2017).

Models for an evaluation of speed limit adjustments

In order to capture different aspects of accessibility in the analysis, three different model systems are compared here: EVA, SAMPERS, and PIPOS. In Table 2 below, some properties of those models are shown. EVA is a tool owned and operated by the Swedish Transport Administration. It is used to calculate and evaluate effects, costs, and benefits of a measure on a road segment in the road transport system.

<table>
<thead>
<tr>
<th>Accessibility measure</th>
<th>EVA</th>
<th>SAMPERS</th>
<th>PIPOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time, traveler surplus, vehicle costs, traffic safety costs, noise and environmental costs</td>
<td>Logsums for work trips, logsums for business trips, logsums for other trips</td>
<td>Accessibility index, work places &lt;30 minutes, time to closest health center, hospital, school, grocery store</td>
<td></td>
</tr>
<tr>
<td>Object</td>
<td>Road segment</td>
<td>SAMS areas</td>
<td>250 m² square areas</td>
</tr>
<tr>
<td>Time horizons</td>
<td>Present, 2040, 2060</td>
<td>2040</td>
<td>Present</td>
</tr>
<tr>
<td>Modes</td>
<td>Road</td>
<td>Road, rail, air, public transport</td>
<td>Road</td>
</tr>
</tbody>
</table>

Table 2. A comparison between the models EVA, SAMPERS, and PIPOS.
The tool evaluates effects on travel time, traffic safety, noise, and environment of a change in road standard or length. In the model, travel demand is static and based on traffic counts such as AADT (Granholm, 2019). The EVA model measures expected change in the value of social costs (aggregated traveler consumer surplus) on a road segment due to a suggested measure. Hence, EVA does not identify geographical pattern representing start and destination for travelers on the road.

The second tool is the Swedish National Travel Demand Forecasting Tool SAMPERS. SAMPERS is a multimodal transport network model owned by the Swedish Transport Administration. It only contains passenger flows on road, rail, air, and public transport networks. The model is by the Administration used as to forecast traffic flows in the transport network, to make impact assessments for larger infrastructure projects, and to evaluate transport policies. It calculates transport demand on networks between different geographical areas, trip frequency, mode choice, and route choice (Boser and Algiers, 2002). In SAMPERS, a spatial division of Sweden known as SAMS areas (Small areas for Market Statistics) is applied. SAMS areas represents geographical areas at sub municipal level, originally composed for labor market data. The detailed spatial division has the benefit to provide a detail that current administrative boarders does not provide. SAMPERS uses logsums to measure accessibility to all other locations from a given SAMS area (Lundqvist and Mattsson, 2002). The logsum thus is a measure of potential, of the different options a decision maker has available. It is only possible to calculate in transport models that use a logit approach to model and describe the behavior of travelers (Van Wee, 2016).

The third model is PIPOS (Pinpoint Sweden). PIPOS is a GIS-platform with a longer history of ownership, development, and maintenance among different public agencies. Currently, the Swedish Agency for Economic and Regional Growth owns, develops, and maintains PIPOS. PIPOS calculates distances and travel time in the road network between different geographical locations. It has been used for detailed analysis of accessibility to places such as located facilities for health care, schools, grocery stores, and workplaces. In the model, travel time is based on legal speed limits. In PIPOS, the spatial division is a grid consisting of 250 m x 250 m squares. For each populated square, PIPOS calculates how travel time by car to the closest primary school, grocery store, health center, and hospital changes due to e.g. a changed speed limit. Using census data over population and workplaces, PIPOS can also calculate the number of jobs that a person at a given position in the grid may reach within a certain time limit.

Results from two scenarios

In this section, two scenarios with different accessibility due to different speed limits are analyzed and compared. In the first scenario (Vision Zero), national speed limits based on the principles of “Vision Zero” are applied. This is the changes suggested by the Transport Administration for 2025, according to their regional plans from 2018. In scenario “Vision Zero”, speed limits are reduced to 80 km/h, on all roads without physical separation between traffic in opposite directions.
The second scenario (Base), is a null scenario where speed limits in the road network corresponds to the current state in 2018, i.e. no alterations are made in the network. Data for both scenarios are from the Swedish National Road Database (NVDB), collected in November 2018.

The solutions from simulations with both SAMPERS and PIPOS are obtained at the national level. However, in order to focus on the impacts of the choice of accessibility measure and model, in this paper we will highlight results from the TEN-T E12-region and especially the part of the region around Umeå. In Figure 7, the differences in speed limits between the two scenarios are shown.

![Figure 7. Speed limit adjustments between scenario Vision Zero and scenario Base in the TEN-T E12-region around Umeå.](image)

In “Vision Zero”, speed limits are increased on some minor road segments and reduced on three roads near city of Umeå; road 363 in the north-west direction, road E12 in between Obbola and Umeå and on the “Blue Highway” road from Holmsund to Umeå. Speed limits are suggested to be reduced on those three roads from 90 to 80 km/h. The reduced speed limits imply that accessibility, measured in terms of travel time or traveler surplus, decreases on all three roads. The EVA model measure accessibility on individual road objects. The change of costs by the reduced speed limit from 90 to 80 km/h, on the TEN-T E12 between Obbola and Umeå Airport, would according to an EVA calculation, increase travel time cost 4.1 times, reduce vehicle costs 0.3 times and increase traffic safety 4.8 times. Taken together, this would justify the reduction. Theoretically, the EVA measure assumes any impacts on society from changed
accessibility is included in this figures. For an extended geographical analysis of the distributional impacts of the changes in accessibility from the speed change, the EVA outcome has to be complemented with other measures.

The SAMPERS and PIPOS models on the other hand, give such geographical information as part of their solutions. Below, Figure 8, shows the change in accessibility between “Vision Zero” and the Base scenario. To the left the impact on SAMS areas using logsums in the SAMPERS-model are shown. To the right, the change in the size of the labor market for people living in each 250 m x 250 m square are shown when the PIPOS-model is used for the simulation.

![Figure 8](image)

**Figure 8.** Change in accessibility measured as logsums over SAMS areas from the SAMPERS model to the left and change in accessibility to workplaces in a labor market within 30 minutes travel time from each place, as shown by a simulation with the PIPOS model to the right.

In SAMPERS, the impact on accessibility of changes in speed limits is focused towards the peripheral areas in east and west, were people lives that use the roads for travel to Umeå city center. This geographical distribution may be compared with the distribution given by the
PIPOS model. In this case, both people living in peripheral and central areas are negatively affected by the increased travel times on the three roads. Since the travel pattern in the SAMPERS-model are based on the logsum attractiveness to, and thus the size of population, in other areas, each area will obtain a weight related to its population in the measure of changed accessibility. People living in the city center are thus by the model not assumed to travel to peripheral regions in the same amount as people living in peripheral areas are traveling to the city center.

Instead, by calculation of the number of *workplaces* that may be reached within a specified time limit, PIPOS produces a more symmetrical, unweighted, geographical pattern. Thus, the measure used by PIPOS instead gives as a result that people living close to the city center also are affected negatively by the speed limit reductions on roads outside the city center, since not all workplaces are located in the city center.

![Figure 9. Simulations with PIPOS. Changes in travel time in minutes to the nearest emergency hospital to the left and to the nearest local health center to the right. Observe that the scale of the map legends are different.](image)

The results from the simulations with PIPOS indicates that the suggested reduced speed limits in some areas will decrease the size of the hypothetical labor market around Umeå with over 40 per cent. While this might seem like a large impact, the majority of negative changes cluster in between 20-30 per cent. An explanation for this is that many workplaces in the Umeå region
are located in peripheral areas connected by the three roads. The strong negative effect in Umeå given by the scenario is an outlier compared to rest of Sweden, with worse results than the average. However, it does suggest that a focus on decreased speed will have a negative effect on accessibility to the labor market within 30 minutes commuting distance. In turn, this may be explained by the fact that traffic flows on those roads are so large that they are on their way to qualify for a standard increase, e.g. with separated meeting lanes. Such an upgrade would lift them out of the “Vision Zero” list of roads that should have reduced speed limits.

The PIPOS results in Figure 9 above add further aspects to the accessibility picture. The figure shows how the travel time in minutes to closest emergency hospital and local health center changes after speed limits have been adjusted. Red color implies increased travel time and reduced accessibility while green is unchanged or slightly improved travel time. Clearly, the geographical pattern from the two measures of accessibility differ. Compared with the impact on travel times to nearest emergency hospital, the impacts on travel time to local health centers are less important. Explanations to this could be that since health centers are much more frequent in Sweden than emergency hospitals, people in general live much closer to a health center, more of the transportation is on local roads not affected by the changes in speed limits and changes in travel time thus is less.

Discussion of the results

In the paper, we have illustrated the multifaceted character of accessibility as a concept when one want a more precise figure of the impacts of changes in accessibility. Accessibility has to be defined and treated carefully, dependent on what aspect of it that is measured. Different metrics describe different aspects. We have shown how a change in a transport network may affect accessibility to different categories of target points differently. The more decentralized structure a group of facilities has the less important are changes on larger roads. Accessibility to centralized facilities instead are more dependent on speed limits on larger roads. Analysis of accessibility thus has to be viewed in a larger context, than merely as a feature of the transport system.

The impact is dependent on both the type of road, and thus the current speed limit, as well as on the number of target point facilities, and thus the degree of decentralization of the facilities. The largest impact of changed accessibility for a single trip may generally be found on changes in national roads of importance for reaching a concentrated facility. Changes on local roads has an impact for those living near the concentrated facility but will generally and in relation to total travel time otherwise be minor. Changes on national roads will be of less importance for the possibility to reach a group of facility that is in plenty and thus decentralized to the neighborhoods of people. In absolute terms, changes on local roads may have minor impacts on both categories of facilities but in relative terms, the impact on decentralized facilities may be larger.

In the study, we compared the results from model simulations in the three model systems
EVA, PIPOS and SAMPERS. While the EVA model only measure the changed accessibility for traffic on the road where a change is made and not the geographical distribution of the changes, it gives a measure that directly is related to the number of vehicles on a road. It also gives a possibility to compare, in cost-benefit terms as a traveller surplus, the relation between costs from increased travel time with the benefits from reduced risk of injuries and fatalities.

SAMPERS and its log sum measure takes care of changes in accessibility but also weights accessibility with respect to number of workplaces or inhabitants in different place. As shown, this may not capture changes in accessibility in directions that not is in the dominant directions of flows. Instead, PIPOS deliver geographical maps that on a detail level show how accessibility to different targets and goals are changed.

In this respect, the PIPOS platform create good opportunities for visualization of the impacts for individual users of changes in the transport system. However, PIPOS does not take care of the amount of traffic on different relations. Hence, the impact on relations with very few travelers will receive the same weight as those with a large amount of travelers. In this respect both EVA and SAMPERS give richer but also more aggregated information.

One shortcoming in the analysis is that PIPOS currently only includes car journeys. Secondly, the analysis does not take into account consequences for freight transport. However, since legal speed limit for heavy trucks generally are lower than the current speed limits, freight is not affected in the same way by adjusted limits. A downward adjustment of signposted speed from 90 km/h to 80 km/h can even result in improvements for these vehicles as the speed difference to other road traffic decreases. However, transport by light trucks is still affected in the same way as traffic with passenger cars.
References


