Impact of higher road vehicle dimensions on modal split

An ex-post analysis for Sweden

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Preface

In many countries, there is a debate to what extent different policies to make freight transport more efficient and sustainable are in conflict. On the one hand, efforts are made to improve the efficiency of road transport. On the other hand, firms are encouraged to shift freight from road to the more energy efficient rail and waterborne modes. The conflict arises because improvements in road transport make it more competitive, frustrating the efforts of alternative modes to capture a larger market share.

Sweden is one of the few countries that increased the dimensions of the heavy goods road vehicles in domestic transport successively. The maximum weight was increased in 1990 (from 51.4 to 56 tonnes), in 1993 (from 56 to 60 tonnes), in 2015 (from 60 to 64 tonnes) and in 2017 (from 64 to 74 tonnes). The maximum length of the vehicles was extended in 1990 (from 24 to 25.25 metres).

The aim of this report is study how the higher road vehicle dimensions in Sweden have affected the modal split of the domestic freight transport market. The ex-post analysis is based on official aggregate and commodity specific statistics. The study has been carried out by Hanna Lindgren, Samuel Lindgren and Inge Vierth, all at VTI.

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Stockholm, December 2017

Inge Vierth
Project leader
Quality review

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Kvalitetsgranskning

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Summary

Impact of higher road vehicle dimensions on modal split. An ex-post analysis for Sweden
by Inge Vierth (VTI), Samuel Lindgren (VTI) and Hanna Lindgren (VTI)

Road freight transport is responsible for a considerable amount of congestion, noise and various forms of air pollution and policy instruments that reduce these negative external effects are therefore on top of many policy-makers’ lists. One of the discussed initiatives to reduce these externalities is to increase the maximum permissible weight and length of vehicle combinations. There are however concerns that higher vehicle dimensions will reduce road transport cost per tonne-kilometre and therefore lead both to a modal shift and to induced demand for road transportation.

The extent to which the introduction of longer and heavier road vehicles attracts freight from competing modes is therefore a crucial question. The purpose of this study is to provide empirical evidence on this matter, by analyzing how the modal split in Sweden has developed following the adoption of increases in the maximum permissible vehicle dimensions.

In this study, we utilize official statistics on freight transport by road, rail and water covering the period 1985 to 2013. We first investigate the extent to which LHVs were adopted following the increases in vehicle dimensions in 1990 and 1993. We then construct time-series for the modal split both on the aggregate level and the commodity group-level and analyze the short- and long-run development.

We show that the share of tonne-kilometres and vehicle-kilometres performed by trucks with a load capacity above 40 tonnes increased substantially in the 1990s, which mainly came at the expense of the vehicles with the lowest capacity. This shows the high degree of incorporation of LHVs in the Swedish vehicle fleet.

Our analysis of the aggregate modal split shows that both the rail and water shares were decreasing from 1985 up until 1995, when the trend reversed for rail transportation. In 2000, rail had regained the market share it had in 1990 and continued to increase in the 2000. Water transportation kept on losing market shares throughout the period of study. The modal share for road transportation developed much in the opposite way. The road share increased steadily between 1985–1990 and continued this way during most of the 1990s, until it stabilized around 60–65 percent. We also show that road and rail have experienced increases in the level of tonne-kilometres since 1990, which implies that the falling rail share between 1990 and 1995 was driven by higher tonne-kilometer growth rates for road transportation than for rail transportation.

Our aggregated freight statistics do not allow us to attribute the development of the modal split during this period of study to a particular event such as the increase in maximum weights in 1990 and 1993. In particular, it is not possible to trace out substitution patterns between the transport modes. The weight reforms are likely to have mattered for the modal development, but so are the economic recession in the early 1990s, the railway sector reforms of 1996 and other structural changes in the transport market. What we do document is the lack of breaks in modal split trends at the weight reforms in 1990 and 1993. On the contrary, the share of each mode is continuing its long-term development.
Sammanfattning

Effekten av högre lastbilsdimensioner på trafikslagsfördelningen i Sverige
av Inge Vierth (VTI), Samuel Lindgren (VTI) och Hanna Lindgren (VTI)

Godstransporter på väg bidrar till en stor mängd trängsel, buller och olika former av luftföroreningar. Policyinstrument som leder till att minska dessa negativa externaliteter ligger därför högt upp på dagordningen hos beslutsfattare. Ett av de diskuterade initiativen för att minska de externa effekterna är att öka den maximala tillåtna vikten och längden på fordonskombinationer. Det finns emellertid oro för att högre fordonssdimensior minskar vägtransportkostnaden per tonkilometer och därför leder till transportslagsskifte och en inducerad efterfrågan på vägtransporter.

I vilken utsträckning införandet av längre och tyngre vägfordon leder till att vägtransporter ökar på bekostnad av konkurrerande transportsätt är därför en viktig fråga. Syftet med denna studie är att ge empiriska underlag till denna fråga genom att analysera hur trafikslagsfördelningen i Sverige har utvecklats efter att ökningar i de maximala tillåtna fordonssdimensionerna har antagits.


Vi visar att andelen tonkilometer och fordonstravaler som utfördes med lastbilar med en lastkapacitet över 40 ton ökade kraftigt under 1990-talet, vilket främst skedde på bekostnad av lätta lastbilar. Detta visar på en hög grad av införlivande av längre och tyngre lastbilar i den svenska fordonsflottan.


1. Introduction

Road freight transport is responsible for a considerable amount of congestion, noise and various forms of air pollution, and policy instruments that reduce these negative external effects are therefore on top of many policy-makers’ lists. One of the discussed initiatives to reduce these externalities is to increase the maximum permissible weight and length of road vehicle combinations. Although there is consensus that longer and heavier road vehicles reduce emissions per tonne-kilometre of goods transported on roads, the impacts on the overall transport system and the possibilities to reach environmental objectives are far from certain and subject to a lively debate (see e.g. Steer et al. 2013; Sanchez Rodrigues, et al. 2015). One concern is that higher vehicle dimensions will lead to a modal shift and induce demand for road transportation. There is a risk that the social benefits from reduced energy consumption and vehicle movements that higher vehicle dimensions may bring about is being offset by induced traffic and freight being shifted away from more environmentally-friendly modes.

The extent to which the introduction of longer and heavier road vehicles attracts freight from competing modes is therefore a crucial question. The purpose of this study is to provide empirical evidence on this matter, by analyzing how the modal split for domestic freight transportation in Sweden has developed before, during and after the increases in the maximum permissible vehicle dimensions. Sweden has been exempt from the EU regulation on vehicle dimension limits ever since its accession to the EU in 1995. The maximum weight was increased from 51.4 tonnes to 56 tonnes in 1990 and then again to 60 tonnes in 1993. Maximum vehicle length was raised from 24 metres to the current limit of 25.25 metres in 1996 (Vierth et al. 2008).

In this study, we utilize official statistics on freight transport by road, rail and water covering the period 1985 to 2013. We first investigate the extent to which longer and heavier vehicles were adopted following the increases in maximum permissible weight in 1990 and 1993. We then construct time-series for the modal split both on the aggregate level and the commodity group-level and analyze the short- and long-run development. We also use the maximum weight reforms to provide some rough estimates of road and rail transport demand elasticities with respect to road transport cost.

Various terms and abbreviations have been used to refer to trucks larger than conventional. Our analysis covers the development from maximum vehicle dimensions of 51.4 tonnes and 24 metres to 60 tonnes and 25.25 metres, which we will refer to as the introduction of longer and heavier vehicles (LHVs). Focus is on the increase to a maximum permissible weight of 56 tonnes in 1990 and 60 tonnes in 1993, and less emphasis is put on the increase in vehicle length in 1996. The increase to 64 tonnes in 2015 is outside the scope of this study. Trucks with weights below 3.5 tonnes are not covered by the freight statistics that we use and are therefore not part of our analysis either.

The outline of this study is as follows. The next section provides a short background to vehicle dimensions regulation in Sweden and a description of other transport-related events that coincided with the weight reforms. In section 3 we give an overview of previous studies on longer and heavier road vehicles in Sweden and internationally. Section 4 describes the methodology and data used in the analysis. We present our results in section 5 and offer conclusions in section 6.
2. Background

Road vehicle combinations higher than conventional have existed for a long time in Sweden. Restrictions on the dimensions were first set in 1968 (37 t, 24 m) and subsequently increased in 1974, 1990, 1993, 1997 and 2015 (see Table 1). The maximum weight was raised to 64 tonnes in 2015 and is planned to increase to 74 tonnes in 2018 (Swedish Transport Agency 2014). Large goods vehicles moving freight in Europe must comply with the vehicle dimension limits set by EU Directive 2015/719, however, Sweden is exempt from the EU legislation ever since its accession to EU in 1995.

The increase in the maximum vehicle dimensions in Sweden coincided with several events that affected the transport sector during our period of study. We list these events in Table 2 and describe them more thoroughly below.

Table 1 Timeline of maximum vehicle dimensions in Sweden. Sources: Vierth et al. (2008) and Swedish Transport Administration (2014).

<table>
<thead>
<tr>
<th>Year</th>
<th>Maximum length (meters)</th>
<th>Maximum weight (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>24</td>
<td>37</td>
</tr>
<tr>
<td>1974</td>
<td>24</td>
<td>51.4</td>
</tr>
<tr>
<td>1990</td>
<td>24</td>
<td>56</td>
</tr>
<tr>
<td>1993</td>
<td>24</td>
<td>60</td>
</tr>
<tr>
<td>1996</td>
<td>25.25</td>
<td>60</td>
</tr>
<tr>
<td>2015</td>
<td>25.25</td>
<td>64</td>
</tr>
<tr>
<td>To be implemented 2018</td>
<td>25.25</td>
<td>74</td>
</tr>
</tbody>
</table>

2.1. Road tax changes

The distance-based tax on diesel-fueled vehicles that had been in place in Sweden since 1973 was abolished in 1993. This was motivated by the technical complexity of the previous system and the need for maintenance and control of the equipment (Swedish Transport Agency 2014). The abolishment of the distance-based tax was estimated to entail a cost reduction of five percent for trucks (Nellldal 2002).

The distance-based tax was instead replaced by a tax on diesel fuels, which applied to the same vehicles that had previously been subject to the distance-based road tax (Swedish Transport Agency 2013). The tax on diesel fuels was in turn abolished in 1995 and replaced by a general energy tax schedule (SFS 1994) with rates differentiated according to environmental vehicle classes (Nilsson et al. 2002).

2.2. Railway sector reforms

The railway reform in 1988 entailed a split of responsibilities between railway operations and infrastructure management. The Swedish Rail Administration was created with the purpose of maintaining the railway lines, while the state-owned SJ continued to operate passenger and freight traffic.

The reform also included rail track charges which were updated several times during the 1990s (SFS 1988). Additional fees for diesel emissions and rail yard operations were added in 1992 (SFS 1991), while the reforms in 1999 introduced a uniform fixed fee and accident charges (SFS 1998). The
maximum allowed axle loading was 22.5 tonnes on about 90 percent of the rail network in 1988 and gradually increased to 25 tonnes in the 1990s and 2000s (Banverket 2006). These changes may have altered the cost structure for rail companies and influenced their cost-competitiveness relative to the competing modes.

A related factor was the deregulation of the market for rail freight transport in 1996. An evaluation of this event showed that the state-owned incumbent continued to dominate and had a tonne-kilometre market share above 80 percent up until 2005 (Vierth & Landergren 2015). The productivity of the rail companies (measured as net turnover per employee and tonnes transported per employee) was reported to have increased by around 45 percent between 1997 and 2014 (Vierth & Landergren 2015).

Table 2 Transport sector events in Sweden.

<table>
<thead>
<tr>
<th>Year</th>
<th>Road</th>
<th>Rail</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td></td>
<td>Railway reform</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>Maximum permissible weight for trucks raised from 51.4 tonnes to 56 tonnes.</td>
<td></td>
<td>Economic recession in Sweden</td>
</tr>
<tr>
<td>1991-1993</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>Lump sum tax on diesel fuels replaces kilometre-based tax on diesel-fueled vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>Maximum permissible weight for trucks raised from 56 tonnes to 60 tonnes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td>Sweden enters the European Union.</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td>Reduction of rail track charges</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td>Split of state-owned rail company in passenger unit (SJ AB) and freight unit (Green Cargo)</td>
<td>Increase in maximum allowed axle loading (STAX) from 22.5 and 25 tonnes.</td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td>Storm Gudrun</td>
<td></td>
</tr>
<tr>
<td>2008/9</td>
<td></td>
<td>Financial crisis</td>
<td></td>
</tr>
</tbody>
</table>

2.3. Economic recession

The financial crisis in Sweden (see e.g. Englund 1999) entailed negative economic growth rates between 1990 and 1993, with GDP falling by around five percent. The economy recovered in the subsequent years with growth rates above four percent. Industrial production followed a similar pattern and had even higher growth rates coming out of the recession.

During the period that we study there was a well-established relationship between growth in freight transport activity and growth in GDP, particular in industrial output (Meersman and Van de Voorde 2002; McKinnon 2007).
Figure 1 shows the relationship between growth rates of GDP, domestic road and rail tonne-kilometres in Sweden. Transport performance by both modes exhibited positive growth rates in the years prior to the recession before dropping to rates below or slightly above zero between 1991-1993. The economic recovery in the subsequent years was accompanied by similar recovery of the transport activity of each mode.

The impacts of higher vehicle dimensions in the 1990s may have been altered by the economic recession, but Figure 1 is inconclusive as to in which way. If road freight transport is more closely linked to economic and industrial activity than the other modes are, the economic recession in the early 1990s may have dampened any increases in the road modal share. On the other hand, this could also mean that road freight transport growth in the subsequent years could be attributed to the accompanying economic growth rather than higher vehicle dimensions.

Figure 1 Annual growth rates of industrial value added, road and rail transport performance 1985-2013. Source: World Bank (2017) and Transport Analysis.

2.4. Storms in the 2000s

In January 2005, the storm Gudrun hit Sweden, affecting 75 million square metres of forest. The subsequent deforestation increased freight transport demand by all modes, but the increase in rail demand of four percent of domestic freight transport was by far the highest. This was attributed to the lack of available trucks, long transport distances and the temporary exemption from rail fees (Riksdagen 2007). There was also a temporarily exemption from the EU cabotage rules following the storm. A potential by-product of these events was a more competitive position of rail transport. Fifteen new terminals were built in the aftermath of the storms and there was increased cooperation between rail freight operators and forestry companies in the development of new logistics solutions for long-distance transport (Riksdagen 2007).
3. Literature review

3.1. International studies

There is a general agreement in academic studies and research reports that adopting LHVs will lead to lower fuel consumption, emissions and costs per tonne-kilometre (Sanchez Rodrigues et al. 2015; Steer et al. 2013; Pålsson et al. 2017). A transfer of freight traffic to road from competing modes is anticipated but the extent of the modal shift is very much debated. There is also uncertainty about the extent of induced traffic, that is, increases in road transport demand not derived from competing modes but from increases in demand due to the fact that freight transport become cheaper with higher vehicle dimensions.

Many studies that investigate how LHVs influence the modal split are ex-ante studies and use modelling approaches. In these modelling studies, the modal shares in a baseline scenario are compared to the shares in a scenario where the vehicle dimensions are increased. The modelling approach requires assumptions about input parameters, which may include price elasticities and the decrease in road haulage price associated with LHVs. The results from the modelling studies vary considerably, ranging from minor to sizeable effects on the modal split (Christidis 2009). Steer et al. (2013) summarize this strand of literature and conclude that the variation in predicted modal shift from adopting LHVs indeed tends to stem from different assumptions regarding own- and/or cross-price elasticities of the modes.

Empirical evidence of the effects of LHVs on modal split is relatively scarce and limited to full-scale implementation of LHVs and temporary trials. In Australia, high capacity vehicles with maximum length of 26 meters and weight of 68.5 tonnes were introduced in 1984 and were permitted extensive network access, including main roads in urban areas (OECD 2011). These vehicles were rapidly incorporated in the Australian vehicle fleet during the 1990s and 2000s. Their share of road freight went from practically zero in 1991 to a third in 2007 (Bitre 2011:123). During this period, both road and rail freight transportation experienced an increase in transport performance, which came at the expense of coastal shipping. In terms of the modal split, rail increased or maintained its market share of long-distance transport and bulk products but lost shares on shorter distances for non-bulk goods (Mitchell 2010). The growth in road freight transport may have been stimulated by the introduction of the high capacity vehicles, but is also said to have been influenced by increased industry demand for reliable and timely delivery as well as improvements in road infrastructure and vehicle technology (Bitre 2011:123).

In the Netherlands, several trials were conducted during the 2000s in which LHVs were allowed temporarily. Ecroys (2009) and Kindt et al. (2011) evaluated the third trial by means of a stakeholder survey of terminal operators, shipping companies and transporters. They found that the modal split in terminals had been unchanged compared to the situation before the trials started (Kindt et al. 2011).

An evaluation of the trial with European Modular Systems in Norway found that the actual usage of longer and heavier trucks during the period of study (2008-2013) had been relatively low. The firms that were using the LHVs did indeed experience large reductions in costs, mainly due to the fact that they could move the same amount of goods using fewer vehicles (Brevik-Wangsness et al. 2014). Trials have also been conducted in Denmark, where vehicle dimension up to 60 tonnes and 25.25 meters were temporarily allowed in 2008. The Danish Road Directorate (2011) found in their analysis that after two years of trials, around 400 EMS-vehicles contributed to 3.6% of annual transport performance and were mainly being used on trip distances of around 200-300 kilometers.

The LHV trials in Germany between 2012 and 2014 granted permission to vehicles with a maximum length of 25.25 meters, compared to the conventional length of 18.75 meters (Limbeck et al. 2017). An evaluation of this trial found that forwarders reported LHVs to bring about a cost advantage of 16% compared to conventional vehicles, given that they managed a utilization rate above 83%.
Although the LHVs required more fuel, the fact that fewer vehicles were required to move the same amount of freight yielded the cost reductions for firms. The report also showed that none of the companies in the study adopted the LHV in favor of rail freight transport. Instead, they were used for pre- and post-haulage in intermodal transport chains.

In Finland, permission to operate high capacity trucks (HCT) of 76 tonnes and 30 meters was granted on designated parts on the Finnish road network. The Finnish Transport Administration’s evaluation of this trial showed that as of September 2017, some 40 HCTs were being used to transport products from the forestry and agriculture industries (Lapp and Likkanen 2017). The experiences from using HCTs was deemed to have been positive. The trucks were considered to be economically viable on routes where there were no infrastructure limits, for large shipment volumes and where loading and unloading would not become considerably harder or more time-consuming. The report found that on trip distances below 100 kilometres, HCTs were considered to be a competitive option only for forestry products, coal, stone, sand and gravel. On longer distances, HCT was considered to have the largest potential for forestry products, food products, iron ore, wastes and container shipments. Modal shift was estimated to be most substantial for forestry products.

3.2. Studies of Sweden

The development of the Swedish freight transport market the last three decades have been investigated in a number of studies. Nellldal (2002) gives a comprehensive review of the freight market in the 1990s and argues that the stagnation of rail freight during this period was due to the increased permissible weight for trucks in 1990 and 1993. He estimates that the reforms jointly entailed a price reduction for road freight of 22 percent at full capacity utilization, which is in line with subsequent estimates (Vierth et al. 2008; Pålsson et al. 2017). The cost reduction lowered freight rates which made rail freight companies less profitable and made it harder for them to finance necessary investment. In a subsequent report by Nellldal et al. (2009), the authors argue that the extension of the road network, lack of industrial railway tracks and increasing foreign trade also help explain the stagnation of rail transportation in Sweden.

A range of studies of Sweden have used model results to analyze the relationship between vehicle dimensions and modal split. Nellldal et al. (2009) investigate the long-term effects of a kilometre tax on heavy road vehicles in Sweden using forecasting models. Based on three scenarios they calculate an own price elasticity for trucks between -0.4 and -0.5, a cross-price elasticity between rail and road of 0.4-0.5 and a cross-price elasticity between water and road of 0.2. The authors argue that the elasticities probably are larger outside market segments where trucks do not compete (such as the markets for ore and oil transportation which are dominated by rail and water respectively).

In a more recent study, Pålsson, et al. (2017) model long-term effects of a permission of 74 tonnes vehicles on Swedish roads. The base scenario is a 25.25-metre-long vehicle combination with a maximum weight of 60 tonnes. They look at three different implementation strategies, where the first (A) is full implementation on all roads, the second (B) is an implementation on designated roads and the third (C) strategy is an implementation on designated roads combined with (two different levels of) a kilometer-based tax for all trucks. Furthermore, each strategy is split into one where only the maximum weight is changed and one where the maximum vehicle length is increased to 34 metres. These implementation strategies are based on two different forecast scenarios: one by the Swedish Transport Administration’s freight transport forecast and one climate target scenario stated by a Swedish Government Official Report. Based on the model results they make environmental impact assessments and conduct cost-benefit analyses.

Since the costs of road transport are assumed to decrease due to increased efficiency of longer and heavier road vehicle combinations, a modal shift from rail and water to road is expected. Pålsson et al. (2017) use the above mentioned cross-price elasticities of Nellldal et al. (2009) which are 0.4 between
rail and road and 0.18 between waterborne transport and road. They further use the own-price elasticity of road transport of 0.4 from de Jong et al. (2010).

Implementation strategies A and B show similar results: tonne-kilometres on road increase both due to induced traffic and because of a modal shift from rail and waterborne transport, but the effects are greater with 34 metres long vehicles. Implementation strategy C, which includes a kilometre tax, results in a negligible modal shift and some induced road traffic. The results for all implementation strategies go in the same directions for both forecast scenarios. However, road vehicle kilometres decrease in all strategies but one (implementation strategy B with the climate scenario) and the greatest reduction of CO2 emissions is given by introducing 74 tonnes vehicles that are 34 metres long in combination with a kilometre tax. All strategies are beneficial from a socio-economic point of view.

Vierth et al (2008) use the Swedish national freight model Samgods to analyze how LHVs affect the Swedish freight market. The authors use the year 2005 with 25.25-metre-long and 60 tonnes heavy trucks as a reference and simulate scenarios where the same quantity of freight is to be moved, but with the same vehicle standards as in most other European countries (maximum 18.75 meters and 40 tonnes). Vierth et al. put a constraint on one of the scenarios, where they do not allow for shifts to other modes. They compare with two other scenarios, one where they increase rail capacity and allow for shift to other modes, and one where they also increase rail capacity but keep Swedish standards for trucks. They argue that since the rail capacity in Sweden is scarce, a change to the European standard would, at least in short term, produce a result similar to the scenario where the modal shift constraint is put and there would be a considerable increase in vehicle kilometres. A “supporting scenario” is also modelled which is equal to the reference scenario, but where capacity for freight trains is strengthened. Elasticities calculated with the Swedish freight transport model are around 0.6 in all scenarios where European standards are introduced (and costs for road freight transportation increase).

In the scenario with 40 tonne-trucks where there is a constraint on rail freight capacity, Vierth et al. show that vehicle-kilometres increase by 24 percent. In the scenario where they allow for modal shift, road vehicle kilometres increase by 14 percent, road tonne-kilometres decrease by 12 percent and rail tonne-kilometres increase by 25 percent. However, roughly half of the tonne-kilometres by rail increase because of the enhanced capacity on rail and mainly to the cost of waterborne transport.

Other studies have conducted similar analysis in the Samgods model. Haraldsson et al. (2012) make a cost benefit analysis of an increase in the maximum weight from 60 tonnes to 90 tonnes. They find that such measure raises the transport cost per vehicle kilometers by 22 percent and reduces the amount of road vehicle kilometres by 21 percent. Vierth and Karlsson (2014) study the effects of allowing road vehicle combinations up to 25.25 meters and 60 tonnes on a designated freight corridor between Sweden and Germany. They find that this increases the tonne-kilometre road freight transportation by 0.5% and decreases rail freight by 0.7%.

Both the Swedish and the international literature exhibit a lack of ex-post analyses of the modal split development following the introduction of longer and/or heavier vehicles. Instead, most of the studies make ex-ante analyses that rely on assumptions of demand elasticities, price reductions and other behavioral changes. The empirical evidence that do exist is often limited to only cover implementations that are restricted geographically or temporally. The implications for the modal split from these studies may not be generalizable to settings where LHVs are permanently introduced on a full scale. We therefore turn to our analysis of the modal split development in Sweden following the higher maximum vehicle dimensions.
4. **Methodology and data**

4.1. **Methodology**

Our analysis of the increase in road vehicle dimension in Sweden is based on several parts. First, we examine the extent of the uptake of LHVVs following the increase of the maximum permissible weight in 1990 and 1993. We then compile a time series of the aggregate modal split in tonne-kilometres for domestic transport and analyze the development between 1985 and 2013. Because the higher vehicle dimensions only applied in Sweden we expect to see the impacts on modal split only for within-country freight transport. We also use the maximum weight reforms to provide some rough estimates of road and rail transport demand elasticities with respect to road transport cost. Finally, we use disaggregated freight statistics to analyze the modal split development on commodity level.

Our approach entails a comparison of the freight transportation before, during and after the vehicle dimension reforms. We identify trends in freight transportation activity for the different modes and try to determine whether the reforms had any impact on those trends. It is important to have in mind that the vehicle dimension reforms do not explain the modal split development alone. The events in the freight market discussed in section 2 are also likely to have mattered for the development, as are other structural changes during this period. Our aggregated freight statistics do not allow for an identification of the impact of higher vehicle dimensions, but do let us analyze the overall development in the Swedish freight market and highlight differences between commodity groups.

4.2. **Data**

Most of our analysis is based on annual freight transport statistics for the period 1985-2013, collected on behalf of the State Railways, Statistics Sweden, SIKA and Transport Analysis\(^1\). The figures cover road, rail and waterborne transportation. Freight statistics for inland waterways were not collected during our period of study and are thus excluded from our analysis. Waterborne transport therefore only includes short-sea shipping.

In our analysis, we mainly show the freight modal split in terms of tonne-kilometers. This measure can be sensitive to outliers so that a small number of heavy shipments on a long transport distance affect the aggregate figure disproportionately. On the other hand, the amount of tonne-kilometers is a common statistic that is easy to compare across countries and other settings and there are standardized methods for calculating it. We do complement our tonne-kilometre measure with the number of vehicle-kilometres and tonnes lifted where we think this adds to the analysis and the data permit.

Rail freight transportation statistics are collected from all relevant stake-holders, including rail operators, infrastructure holders and other companies in the rail transport sector (Transport Analysis 2016a). Waterborne freight statistics are collected from all Swedish ports where vessels have called during the year. Prior to 1996, the statistics were based on a combination of figures from the ports, domestic goods transport and foreign trade statistics (Transport Analysis 2016b).

Road freight transport statistics in Sweden have since 1972 been collected by means of a sample survey (Rosén & Zamani 1993). Freight transport activity is reported separately for different vehicle classes which we utilize in our analysis of the use of LHVVs in the vehicle fleet. The surveys have been conducted annually, except for the period 1987-1993 when only three surveys were made. Statistics Sweden therefore imputed aggregated road freight statistics for the years 1988, 1989, 1991, and 1992, which we use in our analysis. However, commodity-level statistics are completely missing for these years which causes a break in some of our time series.

\(^1\) Different government authorities have been responsible for producing the Official Statistics of Sweden over time. All documents are listed in the list of references.
The road freight data collection method has developed over time. Up until 1999, separate surveys were carried out for national and international road transportation. The sampling scheme for the merged survey underwent a major revision in 2012, which was motivated by a heavy response burden and obsolete stratum definitions (Transport Analysis 2011). The sampling revision means that aggregated measures are comparable over time but disaggregated figures (such as those for commodity groups and vehicle classes) before and after 2012 may not be consistent with each other and should be interpreted with care. However, since our analysis puts relatively low weight on the modal split development after 2012, the change of stratification method should not be a concern.

Another revision of the road freight data collection method was taken in 2014. In the years prior to 2014, Transport Analysis had been validating the official road freight statistics against route registers and other register data. They found that companies in the survey were incorrectly reporting their trucks as unused during the survey period which meant that the road freight transport statistics were underestimated. After having conducted additional surveys to estimate the extent of idle time for trucks, Transport Analysis developed a new method for estimating road freight and implemented it from the 2014 survey and onwards. They also adjusted annual statistics for 2012 and 2013 in retrospect using the new method. The number of vehicle movements, vehicle-kilometres, tonnes lifted and tonnes transported was reported to be 20-30 percent higher with the new data collection method compared to the values from the old one (Transport Analysis, 2015). The adjustment made to the road freight statistics raises the question of how reliable the freight statistics used that we use are, but no study that we are aware of has yet investigated the reliability and quality of these statistics.

We are forced to make a number of restrictions on our data material. Because of the revision of the road freight data collection method, statistics from year 2014 and onwards are not comparable to those from earlier years. We therefore only include figures up until 2013 in our analysis, which means we cannot analyze the modal split development after the increase in maximum permissible weight from 60 to 64 tonnes in 2015.

In most cases we limit the data to only cover domestic transport. Because the higher vehicle dimensions were only applied in Sweden we expect to see the impacts on modal split only for within-country freight transport. Statistics for domestic road freight cover trips by Swedish-registered trucks with goods loaded and unloaded within the country (Transport Analysis 2016c). We assume that lorries registered outside Sweden follow the vehicle dimensions regulation of their home country. Statistics for domestic waterborne transport cover all shipments of goods between Swedish ports while statistics on domestic rail freight transport cover all movements with an origin and destination in Sweden (Transport Analysis 2016a; 2016b).

Because international and domestic rail freight statistics are not reported separately for commodity groups from 1992 and onwards, we include both domestic and international rail freight transportation (on Swedish territory) in our commodity-level analyses. The share of rail freight going abroad can be substantial for some commodities. For instance, international rail transportation of round wood accounted for between 10 and 50 percent of all round wood transportation by rail between 1985 and 1992.

Finally, we exclude from the rail freight statistics all transportation of ore on the Iron Ore Railway Line. This segment makes up about 13 percent of all domestic rail transport. The iron freight trains are transporting ore between mines and ports in Sweden and Norway and there is virtually no competition from trucks in this segment.
5. Results

5.1. The use of LHVs in Sweden

To track the uptake of LHVs in Sweden over time we use the official road freight statistics (from Transport Analysis) segmented by maximum payload of the road vehicle combinations, defined as the sum of the load capacity of the vehicle and the load capacity of the lorries. We divide the vehicle combinations into three categories based on their maximum payload (0-30, 30-40 and 40+ tonnes) and show for each segment the tonne-kilometres (Figure 2) and vehicle kilometres (Figure 3). The maximum payload of a vehicle does not correspond perfectly to a particular set of dimensions. As a rule of thumb however, vehicles of length 24-25.25 meters and weight of 60-64 tonnes, have a maximum payload between 30-42 tonnes (Nelldal 2000).

Figure 2 shows that at the time of the weight limit increase in 1990, trucks with a maximum load capacity above 30 tonnes already accounted for more than 60 percent of the road transport performance. This reflects the fact the maximum permissible weight had been high for a long period of time in Sweden. The share of tonnes kilometres and vehicle kilometres performed by trucks with a load capacity above 40 tonnes increased substantially in the 1990s. The tonne-km share went from 10 percent in 1990 to 45 percent in 2000 while the corresponding increase in vehicle-km was from 5 percent to 30 percent. This clearly shows the high degree of incorporation of LHVs in the Swedish vehicle fleet. The development mainly came at the expense of the vehicles with the lowest capacity, which saw its tonne-km share go from 35 percent in 1990 to 15 percent in 2000.

During the 2000s, the tonne-kilometres by trucks with a load capacity above 30 tonnes expanded moderately and peaked just before the economic recession in 2009. The activity by trucks in the smallest capacity segment declined somewhat during this period. Since 2009, the largest trucks have increased their share of road transport performance considerably.

![Figure 2 Tonne-kilometres (millions) by max load capacity (in tonnes). Source: Swedish national and international road goods transport 1987-2013 and own calculations.](image-url)
To further characterize the nature of road haulage during this period, Figure 4 shows the share of domestic road freight transport in tonnes on short and long haulage distances (below and above 300 kilometers respectively). Clearly, trucks move the most freight on shorter distances, with the share spanning between 90 and 95 percent over the period of study. The share of tonnes on longer distances did increase in the first half of the 1990s, although the change is relatively small.
5.2. Aggregate modal split

After having shown that the use of LHV increased in the 1990s, we next turn to the aggregate modal split development. In Figure 5 we examine the share of each mode (road, rail and waterborne) in total domestic freight transport expressed in tonne-kilometres. The shares are stapled and the index of the shares are shown as dotted lines (1990=100). The index gives the percentage change in the modal shares and is included to better visualize the modal split development. We also provide the index for the development of the total freight transport performance (solid line).

Figure 5 shows that the total freight activity was increasing steadily throughout the period of study with some exceptions, notably the economic crises in the early 1990s and 2009. The rail share was decreasing from 1985 up until 1995 when the trend reversed. In 2000, rail had had regained its 1990 market share and continued to increase its shares in the 2000s. Waterborne freight transport has consistently lost market shares from 1985 and onwards. It went from having 24 percent of the market in 1985, to 19 percent in 1990 and then to 14 percent in 2013.

Road freight transport on the other hand developed in the opposite way. The road share increased steadily between 1985–1990 and continued this way during most of the 1990s, until it stabilized around 60–65 percent. What is noticeable is the lack of break in the modal split trends at the time of the increasing in maximum weights in 1990 and 1993. On the contrary, the share for each mode is continuing its long-term development.

![Figure 5](image-url)

*Figure 5 The mode shares of tonne-kilometres on the left axis and the index of shares of tonne-kilometres on the right axis (1990=100).*

Figure 6 shows the development for the level of tonne-kilometres for each mode (rather than their share of the total). From this figure it is apparent that the amount of tonne-kilometre was growing both for road and rail in the 1990s. The increase in the road share that was documented in the previous figure therefore seems to be driven by the fact that the tonne-kilometre growth rate was higher for road than for rail. It is also noticeable that the level of tonne-kilometres by waterborne transport has gradually declined over time.
5.3. Demand elasticities

An important input when analyzing modal shift is the responsiveness of demand for different modes to changes in transportation costs. A convenient pair of measures that summarize these responses is the own- and cross-price elasticity of demand for a transport mode. They give the change in demand for a particular mode that follows from a change in the transportation cost of the same mode and of a competing mode, respectively. In this section we use the maximum weight reforms together with assumptions of the corresponding road transport cost reduction to calculate the implied demand elasticities.

More formally, the own-price elasticity of road transport demand gives the percentage change in road freight transportation that follows from a percentage increase in road transportation cost. A negative own-price elasticity means that the demand for road transportation falls as the road transportation cost rises. This elasticity is denoted by $\varepsilon$ in this report and given by:

$$\varepsilon = \frac{\text{percentage change in road transport demand}}{\text{percentage change in road transport cost}} = \frac{\Delta Q_{\text{road}}}{Q_{\text{road}}} \frac{\Delta C}{C}$$

where $Q_{\text{road}}$ is the tonne-kilometre freight transportation by road and $C$ is the road transportation cost. The cross-price elasticity of rail transport demand gives the percentage change in rail freight transportation that follows from a percentage increase in road transportation cost. A positive cross-price elasticity means that the demand for rail transportation is increasing as road transportation cost rises. This elasticity is denoted by $\eta$ in this report and given by:

$$\eta = \frac{\text{percentage change in rail transport demand}}{\text{percentage change in road transport cost}} = \frac{\Delta Q_{\text{rail}}}{Q_{\text{rail}}} \frac{\Delta C}{C}$$

2 The price elasticity of demand for a transport mode consists of two effects. The first is the shift in transport volumes between modes because of changing relative prices, holding total transport demand constant. The second is the induced demand for the mode that follows from the fact that freight transportation have become either cheaper or more expensive. In practice, it is difficult to disentangle these two effects when observing changes in demand for a transport mode.
\[ \eta = \frac{\text{percentage change in rail transport demand}}{\text{percentage change in road transport cost}} = \frac{\Delta Q_{\text{rail}}}{Q_{\text{rail}}} \div \frac{\Delta C}{C} \]

Where \( Q_{\text{rail}} \) is the tonne-kilometre freight transportation by rail and \( C \) is, as before, road transportation cost. We use the maximum weight reforms in Sweden to calculate the price elasticities \( \eta \) and \( \varepsilon \). This requires estimates of i) the change in road transportation cost \( \Delta C/C \), ii) the change in road freight transportation \( \Delta Q_{\text{road}}/Q_{\text{road}} \) and iii) the change in rail freight transportation \( \Delta Q_{\text{rail}}/Q_{\text{rail}} \).

For the change in road transportation cost following the increase in maximum weights in 1990 and 1993 we rely on previous estimates of a reduction of around 20 percent (Nelldal 2000; Pålsson et al. 2017). As a robustness check we show calculated elasticities both for an assumed cost reduction of 15 percent and 20 percent. Although a price index for the road transportation industry would have been preferable to use, no such measure is available for our period of study.

For the change in road freight transportation we compare the actual amount of tonne-kilometre by road to estimates of the road transport performance in absence of the increases in maximum weight. We use the same procedure for rail freight, i.e. compare the observed rail transport performance to estimates. The first pair of estimates is a forecast made by the Swedish Transport Council (STC) in 1987 of the tonne-kilometre levels for road and rail for the year 2000. The second pair of estimates is our own forecast of road and rail transport performance for the years 1990-2010, based on an autoregressive model run on data between 1969 and 1987. The figure below shows the actual values of rail and road tonne-kilometres (solid lines) against our own forecasts (dotted lines) and the STC forecasts (dots).

![Graph showing forecasted and observed levels of tonne-kilometres by road and rail. Source: SIKA (2005) and own calculations.](https://example.com/figure7)

**Figure 7.** Forecasted and observed levels of tonne-kilometres by road and rail. Source: SIKA (2005) and own calculations.

Table 3 shows the estimated elasticities evaluated at year 1995 and 2000, for estimates of road and rail freight made by the Swedish Transport Council (STC) and ourselves (VTI) and for different assumptions about the road transport cost reduction (15 and 20 percent). The elasticities are interpreted as the percentage change in demand for each mode following a one percentage increase in road transport cost. For instance, an own-price elasticity of road of -1.38 means that a one percentage increase in road transport cost is associated with a reduction of road tonne-kilometres by 1.38 percent. The elasticities represent both induced demand and modal shift that followed from the increases in maximum weight in 1990 and 1993.
Table 3 Calculated price elasticities. Source: SIKA (2005), Nelldal (2000) and own calculations.

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimate/forecast source</th>
<th>Assumed cost reduction</th>
<th>Own-price elasticity of road</th>
<th>Cross-price elasticity of rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>VTI</td>
<td>-15%</td>
<td>-0.04</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-20%</td>
<td>-0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>2000</td>
<td>VTI</td>
<td>-15%</td>
<td>-1.04</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-20%</td>
<td>-1.10</td>
<td>0.08</td>
</tr>
<tr>
<td>2000</td>
<td>STC</td>
<td>-15%</td>
<td>-1.47</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-20%</td>
<td>-1.38</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Taken at face value, the own price elasticity of road transport demand in column 4 shows only a modest impact on tonne-kilometres by road the first five years. The long run elasticity (evaluated after ten years) range between -1.5 and -1.0, which is roughly in line with the average estimate of -1.0 found in the literature (de Jong et al. 2010). The cross-price elasticity of rail transport demand in column 5 is estimated to be around 0.1 in the short run (five years) and between 0.1 and 0.5 in the long run (ten years). This is also fairly consistent with other estimates found in the literature and slightly lower than the estimate of 0.44 in Nelldal et al. (2009). Even though the elasticities presented here are calculated using different assumptions on cost reductions and tonne-kilometre forecasts, they are likely to be dependent on the input variables used to calculate them and should therefore be interpreted with care.

5.4. Commodity-level modal split

5.4.1. Forestry and mining products

We now turn to the analysis of the modal split development for individual commodity groups. There are five commodities that are fully comparable over the period of study (although data are missing for some years): (1) round wood, (2) sawn, planed goods, (3) chips and waste wood, (4) paper, paperboard and such commodities and (5) earth, sand, gravel and stones.

Figure 8 shows each commodity group’s share of the total tonne-kilometre transported. Together the five commodities constitute 28 percent of all rail freight (excluding the Iron Ore Line), of which round wood and paper make up the majority. The five groups constitute about 24 percent of all road freight, with round wood being the largest group with about 10 percentage points of the total, followed by earth, sand, gravel and stones (6 percentage points). The five groups are less important for waterborne transport, constituting about 11 percent of the total tonne-kilometres. Together, the groups constitute 24 percent of the total tonne-kilometre transportation; round wood is the largest group (10 percent), followed by paper (5.5 percent), earth, sand, gravel and stones (4.5 percent), chips and waste wood (2.4 percent) and finally sawn and planed goods (1.5 percent).
Figure 8 Groups of goods and their shares of total tonne-kilometres transported by each mode in 2013. Note: Domestic transport for road and water, international and domestic transport for rail. Ore on the Iron Ore Line excluded from the rail data. Source: Transport Analysis

Below we present the modal split development for each commodity group. Due to lack of data on waterborne transportation we focus only on the road and rail shares. In all figures, the modal shares are stapled and shown on the left axis, while the growth of tonne-kilometres is shown as lines on the right axis. In other words, the right axes show the percentage change in tonne-kilometres (and not the percentage change in the modal share as in Figure 5).

In Figure 9 the modal split development for round wood is presented. At the time of the first weight reform in 1990, road transportation constituted about 60 percent of the market. This share is increasing substantially during the 1990s and stabilizes at around 75 percent in 2000. After a stable period of time in the 2000s, the rail share is increasing from 2005 and onwards, which coincides with the large amount of forestry products that had to be transported following the storms Gudrun and Per that hit Sweden in 2005 and 2007 (see section 2).

In Figure 10 the modal split for sawn and planed goods is shown. This is clearly a market where the rail has lost its competitiveness to road. Road transport increased its share of the market from 40 percent in 1990 to about 60 percent in 2000 and continued to gain shares up until 2007. It also noticeable that the supply shock of sawn and planed goods due to the storms in 2005 and 2007 did not increase demand for rail transport.

Figure 11 shows the development for chips and waste wood. The road share is considerably higher than the rail share throughout the period of study. The road share increased slightly during the early 1990s and has fluctuated around 95 percent ever since.

As can be seen in Figure 12, the transportation of paper, paperboard and such commodities has been dominated by rail throughout the time period. The modal shares remain very stable during the 1990s while rail transportation gained some of the market in the 2000s.

Finally, Figure 13 shows the development for the earth, sand, stones and gravel, which is clearly dominated by road transportation. Although there are many missing data points, a steady but small increase in the road share is still visible – road went from just below 90 percent of the market in 1986 to having almost all market shares in 2000.
Figure 9 Round wood: tonne-kilometres share on the left axis and index (1990=100) in tonne-kilometres for domestic and international rail freight and domestic road freight on the right axis.

Figure 10 Sawn and planed goods: tonne-kilometres share on the left axis and index (1990=100) in tonne-kilometres for domestic and international rail freight and domestic road freight on the right axis.
Figure 11 Chips and waste wood: tonne-kilometres share on the left axis and index (1985=100) in tonne-kilometres for domestic and international rail freight and domestic road freight on the right axis.

Figure 12 Paper, paperboard and such commodities: tonne-kilometres share on the left axis and index (1990=100) in tonne-kilometres for domestic and international rail freight and domestic road freight on the right axis.
In summary, while the aggregate modal split in section 5.2 showed that the road share increased steadily between 1985-1995 and continued this way during most of the 1990s, the commodity-level analysis highlights different patterns among commodities. In the transportation market for *round wood* and for *sawn and planed goods*, the road share increased substantially during the 1990s. The road share increased slightly in the transportation market for *chips and waste wood* and for *earth, sand, gravel and stones* during this period. In contrast, the shares in the market for *paper, paperboard and such commodities* remained virtually unchanged.

One explanation for the different development is that longer and heavier vehicles are more suitable for certain commodities. For products where the volume, rather than the weight, is limiting the load capacity, higher maximum weights are unlikely to make a large difference. Another explanation is that different commodity groups were differently affected by the events in the transport sector during this time period. Railway sector reforms, fluctuations in economic growth and other structural changes in the transport market may simply have had different impacts in different commodity segments.

### 5.4.2. Road freight transport by distance

We extend our investigation of the commodity-level modal split with a description of the development of the road haulage length distribution. If the introduction of LHV’s decreases road transportation costs, rail freight will reduce its competitiveness towards road freight. The literature discusses this competition in terms of transport distance. Nellström et al. (2009) use the term “break-even-point” which is the transport distance above which rail freight is cheaper than road freight. The break-even-point differs depending on the road and rail vehicles, but the main idea is that the break-even-point will take place at longer transport distances if road transport costs decrease in relation to rail transport costs.

Road freight transportation dominates on shorter trip distances (below some 300 kilometres) whereas rail and road compete more intensely on longer distances (European Commission 2011). Thus, a hypothesis close to hand is that road has gained market shares at the expense of rail on longer distances. In the following analysis we look at the development of domestic road transport on long distances at commodity level.
Figure 14 shows the share of road transportation that takes place on haulage distances above 300 kilometres. The figure presents shares both for each of the five commodities and for total road freight. The two commodities with the highest share of long-distance haulage are paper and such commodities and sawn and planed goods, both fluctuating between 40 and 60 percent. It is noticeable that the increasing road share for sawn and planed goods that was documented in Figure 12 coincides with a higher share of long-distance road transportation for the same commodity group. On the other hand, no such relationship is visible for transportation of paper. The decline in road share in the 2000s for this commodity that was shown in Figure 12 does not correspond to a change in the share of long-distance haulage in Figure 14.

The three remaining commodity groups have all a very low share of long-distance road haulage. The maximum share of round wood is six percent during the period studied. Between 1995 and 2000, a period of increasing road transport and decreasing rail transport of round wood (Figure 9), the longer transportation by road is even decreasing. The group of Earth, sand, gravel and stones, which is highly dominated by road transport, keeps below ten percent of long-distance transport during the whole period studied. The only commodity group showing clear changing patterns is chips and waste wood, which in Figure 11 increases its share of long-distance road haulage from 2007 and onwards. During this period, total road transport of chips and waste wood declines whereas total rail transport increases. One explanation could be that there is an increasing demand in longer transport distances in general.

To summarize, there is no clear structural change of long-distance haulage in all of these five commodities that help explain the development of increasing road market shares. This conclusion is also confirmed by the total road long-distance haulage, which shows no trend before 2007.
6. Conclusions

In this study, we have compiled official freight transportation statistics to investigate how the domestic modal split has developed before, during and after the introduction of longer and heavier vehicles in Sweden. We have concentrated on the increase in maximum permissible weight from 51.4 tonnes to 56 tonnes in 1990 and to 60 tonnes in 1993, rather than on the increase in vehicle length in 1996.

We show that the share of tonne-kilometres and vehicle-kilometres performed by trucks with a load capacity above 40 tonnes increased substantially in the 1990s, which mainly came at the expense of the vehicles with the lowest capacity. This shows the high degree of incorporation of LHV in the Swedish vehicle fleet. This is perhaps not surprising considering the relatively large vehicle dimensions in Sweden that existed prior to the reform in 1990.

Consistent with the freight transportation literature we show that the freight being moved by trucks in Sweden is mainly transported on haulage distances below 300 kilometers. We do document an increase in the share of long-haul distances by road from 1990 and onwards. Together with the finding that LHV were being increasingly used in this period, this gives some support to the notion that LHV are being particularly competitive on longer distances. However, other structural changes on the demand and supply side of the freight market could also explain the increase in the share of long-distance road haulage.

After having shown that the use of LHV increased in the 1990s, we turn to the aggregate modal split development between 1985 and 2013. We show that both the rail and water shares were decreasing from 1985 up until 1995, when the trend reversed for rail transportation. In 2000, rail had regained the market share it had in 1990 and continued to increase in the 2000s. Water transportation on the other hand kept on losing market shares and went from having a quarter of the domestic freight market in 1985 to 14 percent in 2013. The modal share for road transportation developed very much in the opposite way. The road share increased steadily between 1985-1990 and continued this way during most of the 1990s, until it stabilized around 60-65 percent.

We also investigate how the level of tonne-kilometre transportation by each mode has developed during this period. We show that the freight activity by water transportation has declined since 1990 while both road and rail have experienced increases. This implies that the falling rail share between 1985 and 1995 was driven by higher tonne-kilometer growth rates for road transportation than for rail transportation.

Our aggregated freight statistics do not allow us to attribute the development of the modal split during this period of study to a particular event, such as the increase in maximum weights in 1990 and 1993. In particular, it is not possible to trace out substitution patterns between the transport modes. Whether the freight that was shifted away from water transportation benefitted road or rail the most is not apparent. Neither is any shift of freight between road and rail transportation. The weight reforms are likely to have mattered for the modal split development, but so are the economic recession in the early 1990s, the railway sector reforms of 1996 and other structural changes in the transport market. What we do document is a lack of breaks in modal split trends at the weight reforms in 1990 and 1993. On the contrary, the share of each mode is following is continuing its long-term development.

We complement our analysis of the aggregated modal split with a description of the development of the modal split for forestry and mining products. This shows different patterns among the commodities following the weight reforms of the 1990s. The road share increased substantially in the transportation market for round wood and sawn and planed goods, it rose slightly for chips and waste wood and earth, sand, gravel and stones but remained unchanged for paper, paperboard and such commodities.

One interpretation of this finding is that volume and weight characteristics make some commodities more suitable for LHV than others, but without disaggregated data we cannot explore this hypothesis.
further. The different patterns may also reflect differences in the reaction to other transport-related events occurring during this period.

The fact that the aggregated nature of our data limits the extent of our conclusions opens up avenues for further research. One important question is how the firms’ modal choice is tied to their production and logistics decisions. Although the introduction of higher maximum weight puts downward pressure on the freight rate for trucks, transportation cost is far from the only variable that matter for the choice of mode. Other factors in the logistics and production chains may prevent firms from choosing freely between transport solutions. To investigate this issue, the Swedish Road and Transport Research Institute is conducting a study in 2018 of the mode choice response by the Swedish forestry industry to the increase in maximum vehicle weight in 2015. A further examination of the changes in carbon emissions and other environmental impact of LHV is also planned the same year.
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