
Impacts on land use characteristics from ferry replacement projects. Two case studies from Norway

María Díez Gutiérrez a, *, Stig Nyland Andersen a, b, Øyvind Lervik Nilsen a, c, Trude Tørset a

a Norwegian University of Science and Technology, Department of civil and transport engineering, 7491 Trondheim, Norway
b Norwegian Public Roads Administration, Askedalen 4, 6863 Leikanger, Norway
c Rambøll, Fjordgaten 15, 3103 Tønsberg, Norway

Abstract

Fixed links projects are bridges or tunnels that connect two areas separated by geographic barriers. Fixed links reduce dramatically the travel time and provide reliability and flexibility, as often they replace ferry services. This might impact on land use characteristics and travel behaviour. We aim to explain these impacts by making time series analyses of empirical data on two fixed links that connect islands to the mainland on the west coast of Norway. We find that changes in travel time and cost might generate an increase in the attractiveness of the municipalities connected by the fixed links, leading to an increase in population. The greater demand for housing triggers a growth in square metre price for dwellings and construction rates. There is also a higher annual traffic growth than the experienced before the fixed link was opened. Despite that, we do not find either an additional increase in the number of companies or changes on number of employees in the existing companies.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Key words: Fixed link, regional development, land use, housing market, labour market, population

1. Introduction

Fixed links are bridges or tunnels that join areas previously separated by geographic barriers, e.g. fjords. Fixed links might cause significant travel time savings since they often replace ferry services. They remove waiting time, increase speed of travel and provide a flexible link 24 hours 7 days a week. In addition, it is less likely that a fixed link would close due to bad weather conditions. The technology advances make it possible to build longer and more challenging fixed links and, hence, the number of planned fixed links projects have been increasing in recent years. The west coast of Norway is an example as seven ferry crossings are planned to be replaced by fixed links (Statens vegvesen, 2012). This paper aims to improve the knowledge on how these infrastructures affect land use characteristics and society.

* Corresponding author. Tel.: +47-47735050 ; mail: maria.diez@ntnu.no

doi:10.1016/j.trpro.2015.09.078
Fixed-link impacts have been scarcely studied; nonetheless the weakness of the traffic forecast models have been highlighted in Norway by Tørset et al. (2013) and in Denmark by Knowles and Matthiessen (2009). Some ex-post evaluations of fixed links have shown the inaccuracies of the forecasts. The traffic over the international fixed link of The Channel Tunnel between England and France was lower than 50% of what was forecast even five years after the opening (Flyvbjerg et al., 2006). The traffic on the Øresund bridge between Denmark and Sweden was only 81% of the expected traffic the opening year. In contrast, the traffic on the two Danish projects the Great Belt Fixed Link and the Sallingsund Bridge exceeded the forecast by 73% (Knowles and Matthiessen, 2009) and 27% (Skamris and Flyvbjerg, 1996) respectively. In Norway, Trekantsambandet presented an overestimation by 40% and the North Cape by 20% (Lian and Ronnevik, 2010).

The over/underestimation of traffic volumes in the forecasts can be partly explained by the inaccurate prediction of the willingness of the users to pay for a fixed link (Bråthen and Hervik, 1997). This is also mentioned in Knowles and Matthiessen (2009) whose study stresses the lack of data on the physiological effect of substituting a ferry with a fixed link. In the study by Flyvbjerg et al. (2006) 208 road projects, fixed links among them, were evaluated by ex-post analysis. They found that the main reasons for the forecast inaccuracies are within trip distribution and land use development. There is little empirical data explaining changes in destination choice from infrastructure projects. In Norway, population forecasts from Statistics Norway are the key input factors for calculating traffic generation in the transport model. In the current methodology, the model uses the same population forecasts regardless of the possible impact on land use characteristics and society.

Interaction between infrastructure improvements and land use changes has been previously highlighted in Banister and Berechman (2001) and Geurs and van Wee (2004). According to Vickerman (1998) fixed links can promote regional development and cohesion. Integrating communities might widen and optimise the labour market (Louw et al., 2013). This may lead to redistribution rather than growth in the labour market (Gjerdåker and Engebretsen, 2010) (Louw et al., 2013) which is often evident in the commuting data. Our research question for this paper is: What are the possible impacts on land use characteristics and travel behaviour by fixed links, in a Norwegian context? We expect that a fixed link increases the interaction between the affected areas, triggering growth in population and housing market. Moreover, we presume an increase in the number of companies; a wider labour market might result in a growth in commuting between the affected areas.

This paper aims to contribute to the research on fixed link impacts by analysing and combining several types of empirical data over a long time period. The analysed data are traffic volumes, commuting patterns, population, construction and sales of dwellings, and company data. Unlike most of earlier studies, we focus on islands, which have a defined influential area. In addition, we also compare the cases to similar areas without the influence of a fixed link.

In this paper we investigate the ex-post impacts of two fixed links in Norway, presented in chapter 2. In chapter 3, we explain the methodology and the data. The results from the analysis are presented in chapter 4, where we observe possible trend changes before and after the opening of the fixed links. Furthermore, in chapter 5 we discuss the pattern variations, and how the impacts of the fixed links may affect the inaccuracy of the traffic estimations. Chapter 6 comprises the conclusions of this study.

2. Case studies

In this paper, we examine two fixed links, which connect the main islands of the municipalities of Rennesøy and Finnøy to the mainland in the Stavanger area. The study is conducted at municipality level as shown in Figure 1.

We look at a total of six municipalities or regions. Kvitsøy and Strand are municipalities still connected to the city of Stavanger by ferry services. The mainland is divided into two parts: the Stavanger, Sola and Sandnes region (SSS-region) and Randaberg. The SSS-region is well-integrated with a common labour and housing market, thus we look at it as a single entity. We look at Randaberg separately since both fixed links from Rennesøy and Finnøy are joined to the mainland on this municipality.

Figure 2 shows the different connections from the mainland to Rennesøy and Finnøy for three different periods.

Before 1992, Rennesøy and Finnøy were only connected to Stavanger by ferry services, presumably with a frequency of 4 trips per day. The travel time from Rennesøy (Vikevåg) to Stavanger was approximately 150 minutes, including 30 minutes waiting time, with a fee of 148 NOK. The travel time from Finnøy (Judaberg) to Stavanger was 30 minutes.
approximately 180 minutes, including 30 minutes waiting time, with a fee of 208 NOK. The only connection between Rennesøy and Finny was through Stavanger, with a travel time of 330 minutes approximately.

In November 1992 the fixed link Rennfast replaced the Stavanger-Rennesøy ferry service. The toll fee was similar to the previous ferry fee, whereas, the travel time dropped to about 25 minutes. Finnøy became connected to Rennesøy by a new ferry with a higher frequency (14 departures per day). The travel time from Finnøy to Stavanger was reduced to 90 min, including 20 minutes of waiting time, with a 60% reduction of the ticket fee. The travel time between Rennesy and Finny was reduced dramatically to 65 minutes.

In 2006, the toll collection at Rennfast was removed.

In October 2009 the fixed link Finnfast replaced the Rennesøy-Finnøy ferry service. The toll fee was almost 300% of the previous ferry fee, while the travel time decreased to 25 minutes. Moreover, the travel time between Stavanger and Finnøy decreased to 40 minutes.

In 2011 the toll fee at Finnfast was reduced by 25%.
3. Research approach

3.1. Research methodology

The variables selected in the analysis aim to cover a wide range of potential changes in traffic and land use characteristics. We divide them into five main groups: traffic volumes, commuting patterns, population, housing, and labour market.

Fixed link projects might affect the variables at different time periods. Alam et al. (2005) suggested that the interaction between infrastructures and land use characteristics may be perceived in terms of short, medium (6-8 years) and long term effects (15-20 years). This is also mentioned in Wegener and Fürst (1999), where the impacts are divided into very slow, slow, fast and immediate changes. The Organisation for Economic Cooperation and Development (OECD) stresses that ex-post evaluations should be carried out over a long period of time (OECD, 2002). Therefore, we look at the variables from the furthest possible back in time point until 2013/4 in order to detect all possible changes.

Our methodology consists of a time series analysis of the empirical data. We focus on observing the trends and identifying potential pattern changes caused by the fixed link projects. In these case studies, fixed links connect islands which facilitate the identification of the influence area. We validate our findings by testing the hypothesis that the slopes before and after the infrastructure changes are equal. Moreover, we test whether the slopes of the affected municipalities and reference areas are equal. In case of similarities, the changes might be explained by external factors, such as policies or GDP growth for example. Additionally, we combine different variables and hence unclear patterns might be better explained. Doing so, we should get some indication of the impacts of the fixed links in a prior, immediate, short and medium term perspective. The description of each data type, assumptions and specific methods are described below.

3.2. Traffic volumes data

Traffic volumes on the ferries are based on counts provided by the ferry companies from 1986. These counts are mainly from electronic ticketing. However, there are still a few ferries using manual registration, which may lead to potential inaccuracies (Statens vegvesen, 2014a). Traffic volumes on the fixed links are registered from counts by Statens vegvesen. A possible source of error might be the vehicle classification. Before 2001, vehicles on the ferries were classified according to its type (i.e. car, bus). Afterwards, the classification was based on the vehicle length (Statens vegvesen, 2014a). However, the new classification of the road traffic counts started in 2007 (Statens vegvesen, 2014b). We assume that light traffic consists of passenger cars with and without trailer, vans, and vehicles shorter than six metres.

We analyse the average annual daily traffic for light (passenger) and heavy (goods) vehicles, independently. We assume that the traffic volumes to Rennesøy or Finnøy are the volumes on the fixed link minus the traffic on the ferries starting on the islands towards the north. Nevertheless, some traffic volumes on the ferries might have started the trip on the island and hence were not registered in the fixed links. As a consequence, the estimated traffic volumes may be less than the real. Despite that, we assumed that the difference is small so it might be ignored. Traffic volumes are presented in a time series graph in four periods divided by the opening of Rennfast, its toll removal, and the opening of Finnfast. Potential trend changes are verified by linear regressions and the observed volumes are compared to the estimated following these regressions.

3.3. Commuting patterns data

Employee data consist of the number of residents in one municipality working in the others. They are based on several databases from 2000. A possible source of error is that administrative formalities might take some time, so a person may not be registered as an employee even if he/she was employed the year before. Employees registered in the End of the Year Certificates Register (approx. 10%) have not registration on dates, so it is not possible to know when the person started working. For larger enterprises with several establishments this may cause employees to be incorrectly registered as employed by the wrong establishment (Statistics Norway, 2015b). Finnøy municipality includes other islands not connected by the fixed link, and thus few commuters are not affected by the fixed links.
We analyse the development in commuting to/from within the municipalities. We use index 100 in 2000 to visualize the relative changes of the commuters among the municipalities. We test the significance of the differences between the slopes of the number of commuters along the period and if there is a trend break.

3.4 Population data

Population data consist of the number of people residing in each municipality by age ranges from 1986. The statistics are based on population register data from Statistics Norway. Some errors in the registration of the data might occur but these are minimal (Statistics Norway, 2015c).

We analyse the population rates, total and working age, to detect possible changes due to the opening of the fixed links. Population numbers have a large variation among the municipalities, therefore, we represent them using index 100 in 1986. We also test the significance of the difference between the population trends of the municipalities.

3.5 Housing market data

Housing market data consist of the registered sold dwellings from 1990, collected from the Land Registry and Cadastre. A possible source of error is that the properties are registered after the sale has taken place, so for sales late in the year they might be registered the following year. Moreover, some of the properties do not have information about the size and/or the sale price. Moreover, a sale can consist of several buildings both residential and other, e.g. agricultural buildings. The data regarding new buildings are registered in Statistics Norway from 2000. A possible source of error stems from the data registration itself and from the classification of type of dwellings (Statistics Norway, 2015a). The housing data in Finnøy refer only to the two islands (Finnøy and Talgje) connected by the fixed link. We also observe the Norwegian interest rate (Norges Bank, 2015) to relate possible variations to national trends.

We analyse the average square metre price per year of residential houses in each municipality. The data present fluctuations that makes it difficult to observe the trends. Therefore, we use a smoothing method based on the average medium (three values) to reduce the sensitivity of the data. We test the significance of the difference between the trends of the municipalities and look at the relation with the interest rate. We represent the square meter price by the index 100 in 1993. We also observe possible changes in the typology of new dwellings at municipality level.

3.6 Labour market data

Company data consist of all the companies registered in the Brønnøysund Register Centre on the last day of each year since 1996. A possible source of error is the lack of data regarding the company classification, number of employees and profits, depending on the area and the company size. Hence, it is not possible to generalise about these variables, although they are observed as they might indicate the general trend. Another possible source of error is that self-employed individuals might register their home address instead of the firm location. Only the two islands of Finnøy connected by the fixed link are observed.

We examine openings, relocations and closures of firms in the period. We test the significance of the difference between the number of companies in the municipalities. We also look at the types of companies in terms of sector activity (agriculture, forestry and fishing; manufacture; construction; transportation; accommodation, food and leisure activities; shops; other). In addition, we observe the changes in the number of employees for the studied areas.

4. Results

Table 1 summarises some of the impacts that fixed links have on the affected areas (Rennesøy, and Finny). They are represented as differences in cumulative percentage increase using as base years the opening of Finnfast (2009), opening of Rennfast (1992) and the toll removal of the latter (2006). Observed traffic volumes are compared to those expected without the infrastructure change. Commuters outside the islands are compared to the commuters within the municipality. Population, square meter price and number of companies in Finnøy and Rennesøy respectively, are observed in relation to the average population for the reference areas (SSS-region, Strand, Randaberg, and Kvitsøy). Nonetheless, SSS-region is not included in the number of companies, neither Kvitsøy in the analysis of the square metre price due to lack of data.
Table 1. Summary of the fixed link variables over the observed periods

<table>
<thead>
<tr>
<th></th>
<th>2-1 years before</th>
<th>0-1 years after</th>
<th>2-3 years after</th>
<th>4-8 years after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic volumes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Finnfast</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>++++</td>
</tr>
<tr>
<td>Open Rennfast</td>
<td>0</td>
<td>+</td>
<td>+++</td>
<td>++++</td>
</tr>
<tr>
<td>Toll removal Rennfast</td>
<td>0</td>
<td>+</td>
<td>+++</td>
<td>++++</td>
</tr>
<tr>
<td>Commuting patterns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Finnfast</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Open Rennfast</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Toll removal Rennfast</td>
<td>0</td>
<td>+</td>
<td>+++</td>
<td>++++</td>
</tr>
<tr>
<td>Population</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Finnfast</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Open Rennfast</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Toll removal Rennfast</td>
<td>0</td>
<td>+</td>
<td>+++</td>
<td>++++</td>
</tr>
<tr>
<td>Square metre price</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Finnfast</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Open Rennfast</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Toll removal Rennfast</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>++++</td>
</tr>
<tr>
<td>Number of companies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Finnfast</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Open Rennfast</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Toll removal Rennfast</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

n/a No data / 0 No change / + 1-5% / ++ 5-15% / +++ 15-30% / ++++ 30-50% / +++++ 50-75%

4.1. Traffic volumes

Figure 3 shows the changes in average daily traffic volumes to Rennesøy (left) and to Finnøy (right). Five years after the opening of Rennfast, the observed volumes were around 50% more than following a linear regression prognosis without the fixed link. Traffic volumes to Finnøy also increased, as Rennfast became part of connection between Stavanger and Finnøy. After the toll removal of Rennfast in 2006, the traffic volumes to both islands rose with a higher rate than previous years. In Rennesøy, the additional growth in traffic volumes was 20% more than following a linear trend maintaining the toll. After the opening of Finnfast in 2009, the annual traffic growth remained at the same rate. After 2011, the traffic volumes to Finnøy experienced a similar increase than the growth in traffic to Rennesøy after its fixed link was opened.

![Fig. 3. Traffic volumes (a) to Rennesøy and (b) Finnøy. Data adapted from Statens vegvesen (2014a) and Statens vegvesen (2014b)](image-url)

4.2. Commuting patterns

There was an annual growth of commuters to the mainland from all the studied municipalities since 2003. Rennesøy experienced the largest increase. Finnøy and Kvitsøy had a similar steady growth, although the few commuters in Kvitsøy led to some fluctuations. Strand had the lowest annual growth in the period. Commuting numbers between Rennesøy and Finnøy were low and showed very little change.

The number of commuters from/to Rennesøy to/from outside started growing more than the commuters within the municipality a couple of years before the toll removal of Rennfast. The hypothesis that both growth rates were equal can be rejected with a confidence level larger than 95%. The extra growth in cumulative percentage increase reached more than 50% five years after. In the case of Finnøy, there was an additional growth mainly in commuters from Finnøy to outside, 15% five years after the opening of Finnfast.
4.3. Population rates

Figure 4 shows the population changes. The population growth in Rennesøy and Finnøy presented a significant different than the growth in the reference municipalities with a confidence level larger than 95%. There was an increase in Rennesøy population after the fixed link Rennfast opened in 1992. The largest growth was experienced within the working age group (16-67 years). The toll removal of Rennfast in 2006 triggered an increase in the growth. The hypothesis that the growth rates before and after were equal can be rejected with a confidence level higher than 95%. The greatest increase in population was in Rennesøy five years after the toll removal, experiencing a growth of 12% more than the reference areas. Finnøy also presented a trend shift from a modest decrease until 2007 to an increase in population.

![Figure 4. Population index (1986 = 100). Data adapted from Statistics Norway (2015c)](image)

4.4. Housing market

Finnøy and Rennesøy experienced an increase in the construction of residential buildings two years before the opening of the fixed links. The growth was higher compared to the neighbouring municipalities after the toll removal in Rennfast and the opening of Finnfast. There was also a change in the construction of new houses towards higher density dwellings, such as apartment buildings, in both islands.

Figure 5 shows the development of the square metre price in the six studied areas and the Norwegian interest rates. When the interest rates decrease there is an increase in the demand for loans to buy houses. The larger property demand triggers an increase in the square metre prices. Conversely, both the interest rate and the housing prices in Rennnesøy grew from two years before the toll removal in Rennfast. Between 2008 and 2011 there was no price change in Rennesøy, while the others areas experienced a slight growth. After 2011, the prices in Finnøy grew significantly more than in the rest of areas.

![Figure 5. Square metre price (smoothing) index (1993 = 100). Data adapted from the Land Registry and Cadastre. Norwegian interest rate adapted from Norges Bank (2015)](image)
4.5. Labour market

Rennesøy experienced a growth in the number of companies of 183% from 1996 to 2012. This growth was larger than in the neighbouring municipalities. However, there was no trend change due to the opening of the fixed link or toll removal. The hypothesis that the growth rate before and after were equal can be rejected with a confidence level larger than 95%. The increase after 2008 was mainly due to relocation of companies moving to Rennesøy rather than the establishment of new companies. Finnøy did not experience significant changes in the number of companies during the analysed period. Agriculture, forestry and fishing companies dominate the labour market, representing more than the 35% of the total in Kvitsøy, Rennesøy, and Finnøy in 2000. After 2000, the three municipalities experienced a decrease in the share of this type of companies as the number of construction companies increased faster.

5. Discussion

In this paper, we analyse some variables in order to explain changes in land use characteristics and travel behaviour caused by the opening of fixed links. Despite the singularity of these case studies, the findings might be generalised to other infrastructure projects that join areas geographically separated in countries that have people with similar behaviour. Nevertheless, this paper only observe two cases. Another limitation is the lack of data prior to the opening of Rennfast (1992) for some of the variables. Moreover, both case studies are neighbouring islands and might influence each other. The toll removal at Rennfast was only three years before Finnfast opened, and hence it is difficult to separate the effects caused by either of them, particularly for the municipality of Finnøy. In addition, the toll of Finnfast was reduced by 25% two years after the opening of Finnfast.

This research might serve as reference in the way of analysing the empirical data and observing the relations between the potential variables that are affected by fixed links. The methodology selected is time series analysis, looking at the trends over a period of time, before and after the opening of the fixed links. This allows us to detect when the changes actually happen. The use of several variables make it easier to relate the changes and support the findings. In addition, we compare the development in the areas affected by fixed links to other unaffected areas. The case studies are islands, which make easier to identify the area of influence.

The results from the case studies reveal several interesting variations in the regional development. Some changes seem to happen instantly or even some years before the opening of the fixed link, whilst others happen after some years.

Prior effects(2-1 years before the opening of the fixed link and toll removal)

The population in Finnøy started growing slightly more than the average in the reference group two years before the opening of Finnfast. The reason might have been that people were aware of the upcoming opening of the fixed link to Finnøy. Nonetheless, that trend shift in population may have been a consequence from removing the toll of Rennfast rather than the new fixed link opening. On the other hand, Rennesøy did not experience population changes before the opening of Rennfast. Regarding the housing market, the expected travel time savings may have caused a growth in the attractiveness of the municipalities. Christophersen et al. (2000) and Laakso (1997) showed that the improvement in accessibility leads to an increase in housing prices. The increase in housing prices in Finnøy might have been triggered by the decrease in interest rates rather than the upcoming opening of the fixed link. Also supported by a similar increase in the reference municipalities. Conversely, Rennesøy experienced an increase in the housing prices a couple of years before the toll removal in 2006. This increase was extraordinary compared to other nearby municipalities. In this case, it might have been related to the reduction in travel costs since the interest rate also increased. Therefore, regional development might be promoted not only by improvements in travel time but also in travel costs.

The population growth generated an increase in traffic volumes from/to the island. The number of commuters from Rennesøy to the mainland started to increase at a higher rate a couple of years before the toll removal of Rennfast. The same was experienced in Finnøy and Kvitsøy while being connected to the mainland by a ferry service. Thus, it might have not corresponded to a fixed link impact, but rather to a more general growth in the demand for labour on the mainland.
Immediate effects (0-1 years after the opening of the fixed link and toll removal)

The population in Rennesøy experienced a trend shift towards a greater growth after the toll removal compared to the reference group. In contrast, the population in Finnøy grew following the same trend as two years before the opening of Finnfast. The reason might have been explained by the fact that the population in Finnøy started growing more than the average of the other municipalities some years before. Other studies also reveal different population reactions after the opening of a fixed link. Population changes are found in Meijers et al. (2012) but not in Gjerđåker and Engebretsen (2010). Regarding housing prices, the growth remained similar to previous years.

The growth in traffic volumes to Rennesøy immediately after the opening of the fixed link and the toll removal might have been explained by the increase in population or changes in travel destination for existing trips, since the number of commuters remained practically constant. An immediate increase in traffic volumes was also experienced in other fixed link projects close to major cities in Norway as described in Statens vegvesen (2012). There was an increase in the number of commuters from/to Finnøy. This was probably caused by the new residents who maintained their jobs in the mainland. This hypothesis might have been supported by the absence of changes in the growth rate for number of employees on both islands. Nevertheless, there was no trend shift in the traffic growth to Finnøy after the opening of Finnfast. The reason might have been due to the high toll fees, three times more than the fee of the prior ferry service. Hence, the number of leisure or private trips from/to the mainland might have been reduced.

Short term (2-3 years after the opening of the fixed link and toll removal)

While the population growth in Finnøy remained constant, Rennesøy experienced a larger increase in a short term perspective after the opening of the fixed link. The greatest increase in population occurred three years after the toll removal of Rennfast. Increased demand for housing might have contributed to the increase in square metre price. Moreover, there was a change in the construction type from single unit houses to apartment buildings. This might have been influenced by either the closer connection to the urban area, or a widening of the housing market.

The traffic volumes to Finnøy increased in 2011, rather than a short term effect it may have been due to the reduction of the toll fee by 25%. This might have caused a change in the destination pattern, as the number of possible destinations increased within acceptable travel cost. Moreover, previously combined trips might have been also separated. As a result, the interaction from Finnøy to Rennesøy and the mainland and vice versa may have increased. Hence, it is again supported the idea that reducing travel costs may promote regional development and cohesion. There was a slight growth in commuters to/from Finnøy a few years after the fixed link opened. It might have been interpreted as an indication of a more integrated labour market where the skills of the workers correspond better with the requirements of the employers. Growth in commuting due to accessibility improvements are also found in Gjerđåker and Engebretsen (2010) and in Louw et al. (2013).

Medium term (4-8 years after the opening of the fixed link and toll removal)

Medium and long term effects are often associated to labour market. However, Rennesøy had no indications of impacts caused by fixed links on the number of companies or in a change in the sector type. This findings are supported by the studies of Gjerđåker and Engebretsen (2010) and Meijers et al. (2012) which did not find either impacts on labour market. Nonetheless, the studies of Mackie and Simon (1996) and Bråthen and Hervik (1997) found impacts on the labour market caused by fixed links.

Can these impacts explain the inaccuracy of traffic volumes forecasts?

In the case of Finnøy, a population increase might have impacted on the traffic to/from the island and therefore, also on the traffic analysis of the fixed link. In the traffic analysis of Finnfast carried out by the Norwegian Public Roads Administration, they estimated an increase in traffic volumes by 150% from 2009 to 2033 after the tolls were removed (Statens vegvesen, 2009). Nonetheless, if the trend from our time series analysis is prolonged, the traffic volumes would probably reach this level in a few years even with the high tolls on the link.

The estimated traffic volumes in Rennfast were not available.
6. Conclusion

The time series analyses indicate that fixed links do impact on population, housing market and peoples behaviour. Better accessibility generates local development for the areas newly connected, as there might be a change in the destination for private and/or leisure trips. The housing market is affected a few years before the opening of the fixed link, increasing the square meter price and the construction rate of new dwellings. The population increases considerably after the reduction in travel time caused by the fixed links and after the reduction in travel costs caused by the toll removal.

The official Norwegian transport model does not account for new infrastructures as a potential factor for changes in population or land-use characteristics. As a result, there is an over/underestimation of the traffic volumes, also affecting the cost-benefit analysis. This leads to problems in the calculations of the toll fee and road capacity as both are based on traffic volumes. Our analysis shows that in the case of fixed links, changes are significant. These impacts should be included in transport analyses for more accurate assessment of fixed links.

This paper recommends observing the changes on the studied variables for more fixed link projects, using a time series analysis. In addition, we recommend eventually establishing a method to include land-use changes in the transport model.

References

Gjerdåker, A., Engebretsen, O.y., 2010. Local labour market effects of transport investments : The case of two Norwegian regions. 12th World Conference for Transportation Research, 1–22.