The effects of road infrastructure improvement on work travel in Northern Iceland

2014
Journal of Transport Geography 41
DOI: 10.1016/j.jtrangeo.2014.09.009

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Abstract

Work travel is an important alternative to out-migration in rural areas characterized by a limited range of jobs. The size of local labour markets is determined in part by geography and tradition, but advances in transportation have the potential to move people and communities closer together and transform established mindscapes. In Iceland, the dispersion of the rural population, a challenging terrain, and unpredictable weather has made road infrastructure improvements a key component in regional development strategies. A large-scale tunnel project completed in 2010 was intended to strengthen a vulnerable rural area on the northern coast and expand the urban labour market of the regional centre of Akureyri. Traffic surveys and resident surveys conducted before and after the tunnels show a substantial increase in 17–34 km work travel between rural communities. Work travel 61–77 km to and from the regional centre did however not increase. The average length of work travel has shortened but the increase in commuting yielded a net increase in total km commuted. The tunnels increased work travel irrespective of age and education, but increased work travel by women with children in the household in particular. The results suggest that large-scale road infrastructure improvements may substantially strengthen rural labour markets within a driving distance of 15–30 minutes, but may not extend the edge of micropolitan labour markets 45–60 minutes from an urban centre of less than 20 thousand inhabitants.

Keywords

Road tunnel – Commuting – Work travel – Labor market – Rural Iceland

1. Introduction

In many countries, investments in transportation infrastructure have been explicitly promoted to increase occupational mobility and strengthen regional development (Amcoff, 2009; Garmendia et al., 2011; Moss et al., 2004; Partridge and Nolan, 2005; Sandow, 2008). The current case study focuses on the effects of a large-scale road tunnel project in Northern Iceland on the local rural labour market, the micropolitan area of the regional centre and work travel to and from the distant capital region.

Various socio-economic, structural and cultural changes have increased the need for occupational mobility in rural communities. Technological advances and the intensification of production have in particular concentrated and substantially reduced local labour needs in traditional rural extraction industries such as farming, fishing and logging (Hamilton and Otterstad, 1998; OECD, 2006; Seyfrit et al., 2010). In addition, large-scale developments in e.g. oil and gas extraction, mining, and heavy industry tend to far outstrip the capacity of local rural labour markets and draw migrant workers on a regional, national and global scale (Freudenburg and Wilson, 2002; Gramling and Freudenburg, 2006; Johannesson, 2010; Schafft et al., 2013, Tonts, 2010). Similar to the seasonal cycles in more traditional extraction industries, the growth in tourism has further contributed to occupational mobility through seasonal labour shortages in the high season and under-employment in the low season (Boffa and Succurro, 2012; Bosworth and Farrell, 2011; Johannesson et al., 2010; Keith et al., 1996).

Higher educational attainment and the increasing specialization of work have furthermore created ‘thin labour markets’ with few potential jobs in many rural areas (Sandow and Westin, 2010). Educational attainment has consistently been found to

predict both the willingness to commute and the average distance commuted (Cassel et al., 2013; Sandow, 2008; Sandow and Westin, 2010; Öhman and Lindgren, 2003).This is in part because education is associated with occupational specialization and higher income, and higher income in turn makes commuting more economically viable (Cassel et al., 2013; Maoh and Tang, 2012; Sandow 2008; Sandow and Westin 2010). The educational and occupational aspirations of young women and a highly gendered labour market represent a major challenge to the sustainability of many rural communities (Dahlström, 1996; Thorsdottir and Olafsson, 2010). Women are nevertheless less likely to commute and on average commute shorter distances than men, in part because of greater household responsibilities (Cassel et al., 2013; Crane 2007; Haas and Osland 2014; Maoh and Tang 2012). Gender inequalities in opportunities for work travel thus undermine both the occupational opportunities of rural women and the sustainability of rural communities.

At the same time, the boundaries of urban labour markets have been pushed progressively further into rural areas. This is in part driven by urban population growth, rising housing prices and improvements in transportation infrastructure (Garmendia et al., 2011; Grimsrud, 2010; Haas and Osland, 2014; Mitchell, 2004; Renkow and Hoover, 2000). Recent in-migrants from urban to rural areas are in particular more likely to commute long distances for work in urban areas (Champion et al., 2009). However, various technological advances have also made many occupations less dependent on location, enabling more people to work at home, in temporary locations, or literally on the move (Grimes, 2000; Helminen and Ristimaki, 2007; Hislop and Axtell, 2007; Laegran, 2008; Simpson et al., 2003). As careers are increasingly constructed through

series of jobs, contracts and temporary assignments, the distance between home and one specific workplace has become less important in the lifestyle choice of residence. In addition to traditional daily commuting from home to a fixed place of work all year long, a number of people travel to work on a weekly or less frequent basis, even maintaining a second residence closer to the workplace (Amkoff, 2009). Some may also periodically travel considerable distances for seasonal work or short-term assignments and certain occupational groups such as e.g. salespeople, consultants, travel guides and truck drivers travel for a living. Daily commuting is therefore only one aspect of the more general phenomenon of work travel in contemporary societies.

The decentralization of work has contributed to the growth of broad 'exurban' or 'rurban' regions of suburbs, subdivisions, towns, villages and farmland adjacent to cities or major urban centres (Mitchell, 2004; Halfacree, 2008; Halliday and Coombes, 1995). From an urban perspective, such areas provide a variety of residential alternatives and many residents may regard themselves as city people living the rural idyll. From a rural perspective, however, diverse urban labour markets and the local job opportunities created by urban pursuits of the rural idyll may be considered a local resource, analogous to closeness to rich fishing grounds or other natural resources. While the literature emphasizes the flow of work traffic from rural or exurban residential areas to urban work places, rural areas can also be an important source of employment for urban workers (Green and Meyer, 1997; Grimsrud, 2010; Haas and Osland, 2014). In addition to traditional rural jobs, various specialized and professional services must be rendered in rural communities, albeit sometimes on a part-time or occasional basis. Better matches between individual skills and job opportunities thus not only benefits individuals

living in rural or exurban areas, but also strengthens the local economy through the influx of a more specialized workforce from the urban centre.

Smaller urban centres and their surrounding 'micropolitan' areas are in a sense at the intersection of urbanization and counter-urbanization. On one hand, they offer many similar services as larger cities, including educational facilities, developed healthcare, restaurants and coffee shops, speciality shops, entertainment and various artistic and cultural activities. By the same token, such urban centres offer a range of job opportunities for an increasingly specialized workforce and often provide an attractive urban atmosphere. On the other hand, micropolitan areas provide many of the amenities associated with the 'rural idyll, including affordable housing, lower crime rates, less congestion and pollution, more cohesive communities and close proximity to the countryside and often relatively unmanaged nature. In the United States, micropolitan areas of urban centres with 10–50 thousand inhabitants account for a quarter of all counties and 10% of the national population (Vias, 2012). In Norway, areas within 60 minutes travel from a settlement of 15–50 thousand inhabitants account for 17% of the total population and 52% of the population beyond the outer metropolitan fringe of larger cities (Grimsrud, 2010). In Northern Iceland, the 24 thousand inhabitants of the regional centre of Akureyri and surrounding micropolitan area account for about 10% of the national population and 37% of the population beyond the outer fringe of the Reykjavík capital area (Bjarnason, 2011).

2. Transportation investments for regional development

Investments in transportation infrastructure that increase the density of local labour markets make it easier for people to find fitting jobs, simultaneously reducing the need

for out-migration and increasing residential flexibility within regions (Amcoff, 2009; Green, 2004; Sandow, 2008). In principle, shorter distances should lead to less time and money spent on travel and a smaller ecological footprint. However, prior research suggests that reduced commuting costs tend to be met with longer and more frequent commuting, and that the total volume of work travel may be more or less constant on the community level (Haas and Osland, 2014; Limtanakool et al., 2006; Ommeren and Rietveld, 2005; Van Wee et al., 2006).

Interestingly, although prior economic and social appraisals of planned large-scale infrastructure developments are increasingly required, the actual effects are rarely evaluated once projects are completed (Knudsen and Rich, 2013). Existing studies of the labour market effects of such projects have furthermore yielded somewhat mixed results. For instance, the opening of the Øresund bridge between Denmark and Sweden in 2000 appears to have expanded the reach of Copenhagen into the Swedish region of Skån (Knudsen and Rich, 2013; Øresund trends, 2012). In 2011, about 96% of the approximately 18,000 commuters who crossed the 16 km bridge on an average day lived in Skån and worked in Copenhagen. Interestingly, the number of Swedish commuters was roughly equal to the number of Danes that have moved to Skån to take advantage of lower housing prices while continuing to work in Copenhagen. In Spain, Garmendia et al. (2011) found that while motorway improvements between Madrid and Andalusia increased territorial cohesion through commuting by car and bus, high speed rail predominantly increased long-distance commuting of about one hour between the provincial centre of Ciudad Real and the national capital of Madrid, but had limited effect beyond the one-hour threshold.

In sharp contrast, the 50 km Channel tunnel and 35 minute high-speed rail connection between Folkestone in Kent and Coquelles in Pas-de-Calais that opened in 1994 appears to have had limited effects on regional development in either Britain or France (Anguera, 2006; Thomas and O'Donoghue, 2013). While there is some degree of long-distance commuting from Folkestone to London on one hand and from Coquelles to Paris on the other, there appears to be virtually no cross-border commuting between Kent and Pas-de-Calais. This may in part be explained by a combination of language and cultural barriers, time tables and train costs (Thomas and O'Donoghue, 2013). However, it should also be noted that Kent is within an hour from London and Pas-de-Calais less than two hours from Paris. The less densely populated regions are not likely to compete with such vast metropolitan labour markets as a destination for long distance commuters. The labour market effects of infrastructure megaprojects thus appear to be contingent upon the geographical configuration of larger cities and less populated areas, as well as various economic, logistic and cultural considerations.

Studies of the impact of transportation improvements on work travel in more rural settings appear to be quite sparse. A tunnel and set of three bridges completed in 2001 brought most of the 30 thousand inhabitants on three islands in Southern Norway within one hour of the Haugesund area of about 100 thousand inhabitants. This promoted new forms of commuting between the islands and a 137% increase in commuting towards the regional centre in the period 2000–2007 (Lian and Rønnevik, 2010). A decrease in travelling time from about an hour to about half an hour between Stord with just under 18 thousand inhabitants and Bømlo with about 11 thousand appears to have increased commuting in both directions by about 40% (McArthur et al., 2013). Interestingly,

however, the 11 km long tunnel connecting Kvinnherad with a population of about 13 thousand and Odda with a population of about 7 thousand appears to have had a direction-specific effect (McArthur et al., 2013). Prior to the tunnel, commuting was almost exclusively from the smaller to the larger community. The decrease in commuting time from more than two hours to less than an hour was associated with a massive increase in commuting from the larger to the smaller community but does not appear to have affected commuting towards the larger community in the long run. As a result, total commuting between the two communities quadrupled with approximately three out of four commuting from the larger to the smaller community.

A tunnel opened in 1995 and associated road improvements completed in 2005 reduced travel time between the towns of Førde and Florø in Western Norway by about 25 minutes. The commuting time of less than one hour resulted in a 64% increase in commuting between the two towns of about 12 thousand inhabitants each, in a region of roughly 30 thousand inhabitants. However, a set of three tunnels and four bridges completed in 1999 did not appear to have any significant effects on commuting patterns among the three thousand inhabitants of island of Magerøya in Northern Norway. The project reduced travel time from the island to an equally rural mainland area in the region of Finnmark from 45 minutes by ferry to about 20 minutes by car. There was no increase in commuting to the urban centre of Alta about three hours away, with a population of almost 20 thousand inhabitants. Lian and Rønnevik (2010) conclude that road infrastructure improvements in rural areas may primarily strengthen local labour markets within a commuting distance of one hour in areas of at least 30 thousand inhabitants.

The current study adds to understanding of the effects of road infrastructure improvements on rural labour markets by examining the effects of a large scale road tunnel project on work travel in Northern Iceland. The design of the study allows an examination of the effects of the tunnels on short-distance work travel in the expanded rural labour market of fishing villages and farms, the extent to which the towns have been integrated into the micropolitan area of the regional centre, long-distance commuting to the distant capital area of Reykjavík, changes in the frequency and total volume of work travel and variation in the effects of the tunnels by socio-demographic factors.

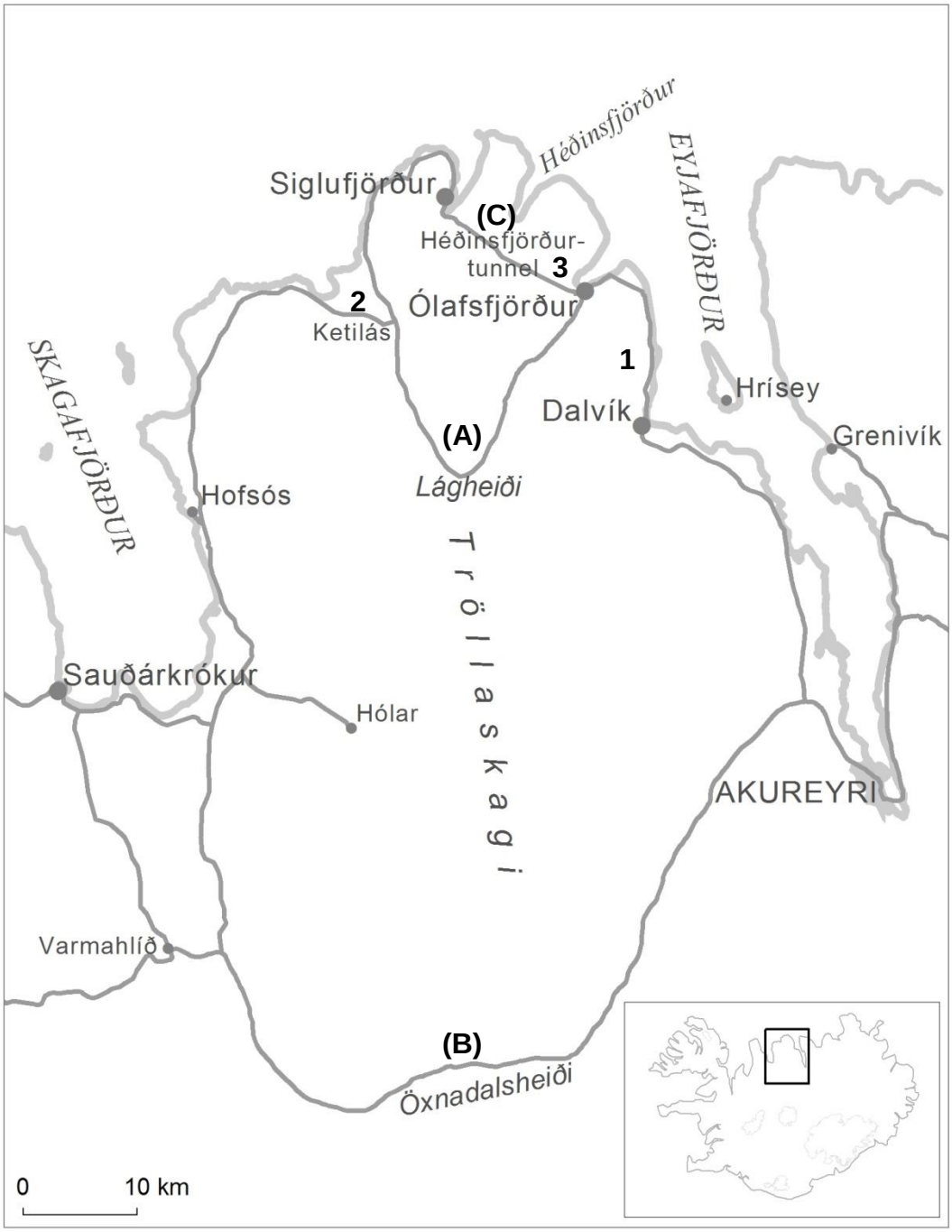
3. Icelandic regional policy and the Héðinsfjörður tunnels

The dispersion of the rural population in Iceland, a challenging terrain of fjords and mountain ranges, and unpredictable weather has made road infrastructure improvements a key component in Icelandic regional development strategies (Althingi 2012, 2014). In particular, bridges and road tunnels have played an important part in connecting settlements, strengthening public services, and creating larger and more diverse labour markets in rural areas (Bjarnason and Olafsson, 2014; Hjalmsdottir et al., 2011). The ambitious national road tunnel plan adopted in 2000 listed 24 viable tunnels in addition to the five tunnels already completed (Icelandic Road Authority, 2000). Among the three projects prioritized were twin tunnels from the deserted fjord of Héðinsfjörður, one running 3.7 km to Siglufjörður (pop. 1,200) in the west and the other 6.9 km to Ólafsfjörður (pop. 800) in the east.

Similar to many other fishing communities in Iceland, the two towns of Ólafsfjörður and Siglufjörður experienced considerable prosperity and population growth in the first

half of the twentieth century, followed by a long decline associated with concentration in the fishing industry and declining labour needs in land-based fish processing (Agnarsson, 2007; Bjarnason, 2011, 2012; Hall et al., 2002). The development of other economic activities has been hindered by difficult transportation and a small population base. A lack of opportunities for education and work, services and leisure activities, and isolation from the mainstream of modern society has resulted in a decline in the combined population of these two towns from about four thousand in 1950 to about two thousand in the beginning of 2014 (Bjarnason and Stefansson, 2010; Statistics Iceland, 2014b, 2014c).

Prior to the opening of the road tunnels, Ólafsfjörður was already at the edge of the Northeast region of Iceland (pop. 29,100). The town was 17 km north of the neighbouring fishing town of Dalvík (pop. 1,400) and 61 km north of the regional centre of Akureyri (pop. 18,000) where the regional hospital, a small university and various industries and services are located. In contrast, Siglufjörður was at the edge of the sparsely populated Northwest region (pop. 7.200), 96 km northeast of the small regional centre of Sauðárkrókur (pop. 2.600). For much of the year it was possible to travel 62 km from Siglufjörður to Ólafsfjörður via the Lágheiði mountain pass (marked A in Figure 1), and from there onwards to Dalvík and Akureyri. When the gravel road through the mountain pass was closed in winter conditions, however, Siglufjörður was 192 km from Akureyri, 216 km from Dalvík and 233 km from Ólafsfjörður on the national highway across the Öxnadalsheiði mountain pass (marked B in Figure 1).



(A) Gravel road between Ólafsfjörður and Siglufjörður
(B) National highway connecting Ólafsfjörður and Siglufjörður
(C) The Héðinsfjörður tunnels

1. Traffic surveys south of Ólafsfjörður
2. Traffic surveys south of Siglufjörður
3. Traffic surveys between tunnels

Figure 1
Road connections in the area of study

The Héðinsfjörður tunnels opened in October 2010 (marked C in Figure 1).shortened the distance between the two towns to accessible 17 km year round. The tunnels in effect doubled the size of the local labour market, offering both employers and employees new opportunities for matching individual skills with available jobs. A larger population base also created new opportunities for various services and industries in both towns. The tunnels furthermore allowed the merger of the two towns into the municipality of Fjallabyggð, resulting in the reorganization of governmental and municipal jobs in both towns.

Although the two towns were similar in size and shared many social and economic characteristics, the tunnels affected their relative geographical position in very different ways. Apart from the new proximity to Siglufjörður, the tunnels only minimally increased occupational opportunities in Ólafsfjörður by an improved 113 km road via Siglufjörður to the small northwest regional centre of Sauðárkrókur (pop. 2,600) and 403 km to the capital region (pop. 208,800). In contrast, the tunnels in effect moved Siglufjörður from the sparsely populated Northwest region to the more densely populated Northeast region with only 34 km to the fishing town of Dalvík and 77 km to the regional centre of Akureyri. Siglufjörður thus shared with Ólafsfjörður the impact of a substantially denser local labour market, but was also moved considerably closer to other potential places of employment in the Northeast region.

The tunnels also created new opportunities for other communities in the Northeast region. The addition of the 1.200 residents of Siglufjörður represented a 5% population increase in the Akureyri micropolitan area that had only enjoyed 0.6% population growth per year in the previous decade. The tunnels enabled a deeper penetration of urban

services as travel time from Akureyri to Siglufjörður was reduced to about an hour all year round. In addition to strengthening services rendered in Akureyri, the tunnels thus made it viable for various professionals and specialized workers living in Akureyri to provide various services in Siglufjörður. Residents of Dalvík may also have gained some new work opportunities because of the proximity to the slightly smaller Siglufjörður.

4. Expected effects of the tunnels

The Héðinsfjörður tunnels to a certain extent provide a natural experiment of the impact of road infrastructure on rural labour markets. The different implications of the tunnels for the two towns allows a distinction between the effects of an extended rural labour market with more essentially similar jobs on one hand and better access to a much larger and more diverse micropolitan Akureyri labour market on the other. The small size of the towns and easily monitored roads in the region make it possible to map all possible directions of work-related traffic to and from the two towns.

A considerable increase in work travel is expected between Ólafsfjörður and Siglufjörður. In addition, increased work travel is expected from Siglufjörður to the similar fishing village of Dalvík and to the much regional centre of Akureyri. An increase in work travel is however not expected from Ólafsfjörður towards Sauðárkrókur or the capital region in the west. The tunnels can also be expected to impact in-bound work traffic from other places to the two towns. In particular, a substantial increase in service-related work traffic is expected from Akureyri to Siglufjörður. Some increase in work traffic from Dalvík to Siglufjörður can also be expected.

In line with previous research, the propensity for work travel can be expected to vary between socio-demographic groups. Males are thus expected to be more likely to travel to work than females, in particular when there are children in the household (Cassel et al., 2013; Crane 2007; Haas and Osland 2014; Maoh and Tang 2012). It is possible that the tunnels offer women more freedom to work outside their home town and that gender differences will therefore diminish, in particular among mothers. However, it is also possible that the tunnels will allow husbands to work further afield, thereby increasing gender differences in mobility (Hjalmsdottir, 2012; Thorsdottir and Olafsson, 2010). This study provides an opportunity to test these two alternative expectations.

Commuting has often been found to peak among people in their early thirties (Maoh and Tang, 2012), but this association is generally weak and somewhat inconsistent. For instance, Sandow (2008) found the probability of commuting long distances in rural northern Sweden to be highest in the youngest age group, while Cassel et al. (2013) did not find a significant association with age in rural central Sweden. Previous research also suggests that more educated people can be expected to travel more for work (Cassel et al., 2013; Sandow, 2008; Sandow and Westin, 2010; Öhman and Lindgren, 2003). Recent in-migrants to rural areas have also been found more likely to commute long distances for work (Champion et al., 2009). The tunnels can be expected to increase work travel of university graduates, skilled workers holding a trade certificate and recent in-migrants.

5. Data and methods

This research is part of a project aimed at evaluating the social, economic and cultural impact of the Héðinsfjörður tunnels in Northern Iceland (Bjarnason and Stefansson,

2010). The project was implemented by a research team at the University of Akureyri in Northern Iceland and funded by a research grant from the Icelandic National Road Authority. This project draws upon two of the datasets produced by the project.

Traffic surveys were conducted in summer and winter, prior to the tunnels in 2009 and after the tunnels in 2012. In the year before the opening of the tunnels, all traffic on the main roads in northern Tröllaskagi peninsula was stopped at two strategic locations; (1) on the road south of Ólafsfjörður and (2) at the crossroads in Ketilás south of Siglufjörður (see Figure 1). In 2012, traffic was stopped at the same locations, as well as (3) at the new Héðinsfjörður tunnels between the two towns. The drivers were asked seven questions, including the primary purpose of their trip, their place of residence, and the origin as well as the destination of their current trip. Additional information coded by the researchers included the number of passengers, used to calculate the number of work trips based on individuals rather than cars.

Following the traffic survey methodology developed by the National Road Authority (Brynjarsson, 2009), all traffic was stopped on eight days; between 8 AM and 11 PM on a Thursday and a Saturday in July and November in 2008 and 2012. The daily average number of trips each year was calculated using Thursday data as a proxy for five-day weekday traffic and Saturday data as a proxy for two-day weekend traffic. The resulting weighted figure can be compared to actual data for each year obtained by automatic traffic counters on the road south of Ólafsfjörður and southwest of Siglufjörður.

Table 1 shows that a total of 8,098 drivers were stopped during the eight survey days, including 1,488 drivers on work trips. The overall volume of winter traffic is 42% of

summer traffic, reflecting the extent of tourism in the area. Work trips in winter were however 83% of summer work trips.

Table 1
Description of traffic surveys in 2009 and 2012

	SUMMER			*WINTER*		
	2009	*2012*	*Change*	*2009*	*2012*	*Change*
Number of vehicles stopped						
All traffic	2.276	3.415	50,0%	863	1.544	78,9%
Work-related traffic	288	523	81,6%	243	434	78,6%
Average number of travellers						
All traffic	2.2	2.2	0,0%	1.8	2.1	16,7%
Work-related traffic	1.7	1.5	-11,8%	1.5	1.8	20,0%
Daily averages at fixed positions						
South of Ólafsfjörður, survey est.	644	841	30,6%	297	392	32,0%
South of Ólafsfjörður, fixed counters	618	750	21,4%	282	354	25,5%
South of Siglufjörður, survey est.	505	390	-22,8%	186	108	-41,9%
South of Siglufjörður, fixed counters	376	332	-11,7%	128	68	-46,9%
Between tunnels, survey est.	---	783	---	---	421	---
Between tunnels, fixed counters	---	742	---	---	392	---

The estimates of summer and winter traffic can be validated by comparing them with fixed traffic counters that register every vehicle that passes certain points on Icelandic highways (Icelandic Road Authority, 2014). As can be seen in Table 1, the traffic stops somewhat overestimate traffic in both summer and winter. The overestimation in summer is likely because July is close to the peak in tourist traffic, while average winter traffic in this area is affected by periods of heavy snow and risk of avalanches later in the season. The data nevertheless appear to be a reasonable approximation of annual traffic in the region.

Resident surveys in Ólafsfjörður and Siglufjörður were conducted in-home in October and November 2009 and 2012. All residents 18 year and older were asked to

respond to a standardized ten-page questionnaire on various topics. In 2009, the questionnaires were distributed and collected by research assistants but in 2012 respondents could either send their questionnaire in a pre-stamped envelope or respond to the survey electronically. A total of 732 questionnaires were completed in 2009 and 416 in 2012. Based on the census conducted as part of the project, the estimated response rate was 53% in 2009 and 30% in 2012. Differences in data collection methods are likely responsible for the lower response rate in 2012. For the purposes of the current study, only data from the 884 working-age respondents are used.

Table 2
Descriptive statistics for resident survey

		2009			2012		
	Range	Mean	S.E.	St. dev.	Mean	S.E.	St. dev.
Town							
Ólafsfjörður	0–1	.399	.020	.490	.393	.028	.489
Siglufjörður	0–1	.601	.020	.490	.607	.028	.489
Gender							
Male	0–1	.485	.021	.500	.459	.029	.499
Female	0–1	.515	.021	.500	.541	.029	.499
Age group							
18–25 year old	0–1	.114	.013	.318	.089	.016	.285
26–40 year old	0–1	.209	.017	.407	.171	.022	..385
41–66 year old	0–1	.677	.019	.468	.741	.025	.439
Residence in community							
Less than five years	0–1	.093	.012	.291	.066	.014	.248
Five years or more	0–1	.907	.012	.291	.934	.014	.248
Education							
University degree	0–1	.135	.014	.342	.180	.022	.385
Trade certification	0–1	.250	.018	.434	.295	.026	.457
Other	0–1	.630	.020	.483	.538	.029	.499
Family							
Children under 18	0–1	.409	.020	.492	.331	.027	.471
Dependent variable							
Monthly work travel	0–1	.152	.015	.359	.285	.026	.452
Weekly work travel	0–1	.100	.013	.300	.177	.022	.382
Daily work travel	0–1	.054	.009	.225	.085	.016	.280
Sample size		579			305		

Table 2 shows that 60% of the responses in 2009 and 61% of the responses in 2012 were from residents of Siglufjörður, compared to 60% in the actual population of Fjallabyggð in these age groups (Statistics Iceland, 2014c). The proportion of recent in-migrants that had lived less than five years in the community was reduced from just over 9% in 2009 to less than 6% in 2012. This is in line with the decrease in registered in-migration from 7% in 2009 to 5% in 2012 and the decrease in out-migration from 10% in 2009 to 7% in 2012 (Statistics Iceland, 2014a).

Respondents in the age group 18–25 were 9–11% of the samples in 2009 and 2012, compared to 17–19% in the target population. This is in line with research demonstrating that Statistics Iceland overestimates the actual number of young people in that age group in Fjallabyggð by 15–18% (Bjarnason and Olafsson, 2014). This is primarily because young people studying elsewhere are frequently still registered in their community of origin. The age group 26–40 is 17–21% of the sample, compared to 24–25% in the target population. Finally, the age group 41–66 is 68% of the target sample in 2009 and 74% in 2012, compared to 57–58% in the target population. Women are 52–54% of the respondents, compared to 43–47% in the actual population, Women and older respondents thus appear to somewhat more likely to respond to the surveys.

The validity of other characteristics of the sample cannot be assessed by comparison with figures from Statistics Iceland, but their reliability can be evaluated by comparing them between the two data points. In 2009, 41% of the respondents had children under the age of 18 in the household, compared to 33% in 2012. In 2009, 14% of the respondents held a university degree compared to 18% in 2012. A total of 25% of

respondents held a trade certificate in 2009 compared to 29% in 2012. The percentage holding neither was 63% in 2009 and 54% in 2012. Less educated residents and those with children under the age of 18 thus appear to have been somewhat less likely to participate in the 2012 than the 2009 survey.

It should also be noted that the increase in self-reported work travel is less than actual traffic stops would suggest. This may in part be due to differences in measurement between a retrospective in-home survey and actual traffic stops. For instance, travellers making multiple trips in a certain time frame are only counted once in the in-home survey but have multiple odds of being included in the traffic survey. However, this discrepancy may also be due to a survey bias either overestimating work travel prior to the tunnels or underestimating the extent of such travel after the tunnels. In either case, it is possible that an underestimation of the magnitude of increase in traffic may mask some of individual-level differences in the in-home survey.

6. Results

The following analysis is organized in two parts. First, the results of the four traffic surveys are used to estimate the actual number of work trips, the average length of such trips and the total number of km travelled before and after the tunnels. Second, the results of the two in-home surveys are used to estimate the effects of the tunnels on self-reported daily, weekly and monthly work travel in each town by age, gender, length of residence, family circumstance and education, and to test potential interactions between these factors.

Table 3 shows the average number of work trips per day between the two towns within the municipality of Fjallabyggð, outbound work traffic to other areas and in-bound work traffic to the two towns. Prior to the tunnels, there were about 16 work trips between the two towns per week on average. After the opening of the tunnel, the number of work trips between the two towns increased 17-fold to an average of 272 per week in 2012. Residents of Siglufjörður constitute 60% of the total population of the two towns and account for 61% of the work-related traffic between them in 2012. After the opening of the tunnels the origin of work trips between the two towns is thus proportionate to population size.

Outbound work traffic to other areas also increased significantly after the tunnels opened. Both towns experienced a significant increase in such travel to nearby Dalvík and, interestingly, the distant capital area about 400 km to the southwest. Neither town experienced a significant change in work travel to either the northeast regional centre of Akureyri or the smaller northwest regional centre of Sauðárkrókur. In fact, the average of 34 work trips per week to the regional centre of Akureyri 61–77 km to the southeast is almost identical to the average of 32 work trips per week to the capital area of Reykjavík 386–403 km to the southwest.

Before the tunnels, nearby farming communities to the west were the most important destinations of work trips from Siglufjörður, while Akureyri and Dalvík were most important destinations from Ólafsfjörður. After the tunnels, out-bound work traffic from Siglufjörður was evenly distributed between Dalvík and Akureyri in the east and Sauðárkrókur, the capital area and other areas in the west. In contrast, about half the

out-bound work traffic from Ólafsfjörður after the tunnels was for Dalvík and about a quarter each to Akureyri and the capital area.

Table 3
Commuting in Fjallabyggð according to traffic survey based on number of travellers

	Siglufjörður		Ólafsfjörður		Fjallabyggð total	
	2009	*2012*	*2009*	*2012*	*2009*	*2012*
Average number of trips per week						
Within Fjallabyggð	***6***	***166***[c]	***10***	***106***[c]	***16***	***272***[c]
- To Ólafsfjörður	6	166[c]	---	---	6	166[c]
- To Siglufjörður	---	---	10	106[c]	10	106[c]
From Fjallabyggð	***35***	***58***[b]	***50***	***94***[c]	***85***	***152***[c]
- to Dalvík	0	10[c]	23	43[b]	23	53[c]
- to Akureyri	9	12	20	22	29	34
- to Sauðárkrókur	7	9	0	0	7	9
- to Capital region	2	9[a]	0	23[c]	2	32[c]
- to other locations east	0	5[a]	3	2	3	7
- to other locations west	17	13	4	4	21	17
Into Fjallabyggð	***75***	***176***[c]	***162***	***124***[a]	***237***	***300***[c]
- from Dalvík	6	24[c]	35	41	41	65[b]
- from Akureyri	23	90[c]	99	47[c]	122	137
- from Sauðárkrókur	18	19	3	1	21	20
- from Capital region	13	20[a]	16	19	29	39
- from other locations east	8	7	7	4	15	11
- from other locations west	7	16[a]	2	12[b]	9	28[c]
Total travel for work						
Total number of trips per week	116	400[c]	222	324[c]	338	724[c]
Average round trip (km)	349	154[c]	162	106[c]	226	133[c]
Total km travelled per week	40.484	61.600	35.964	34.344	76.448	95.944

a) p. < .05 b) p. < .01 c) p. < .001
Tests of statistical significance for number of work trips are t-tests based on proportions of the Fjallabyggð population aged 18–66. Tests of statistical significance for average distances travelled are t-tests based on sample variances.

It is important to note that both before and after the tunnels the number of in-bound work trips to the two towns was higher than the number of out-bound trips from the two towns. This is an important reminder that rural areas may be an important destination of

work traffic. There is a statistically significant 27% increase in work trips into Fjallabyggð after the tunnels but this effect varies greatly between towns. Inbound work trips to Siglufjörður increased significantly by 101 trips per week or 135%, while the corresponding number for Ólafsfjörður decreased significantly by 38 trips per week or 23%. The change primarily involved significantly more in-bound traffic from Akureyri to Siglufjörður and significantly less in-bound traffic from Akureyri to Ólafsfjörður. Before the tunnel, only 19% of work trips from Akureyri to the area were to Siglufjörður but after the tunnels Siglufjörður accounted for 66%, which is slightly more than proportionate to population size. Siglufjörður also experienced significantly increased commuting from Dalvík and the capital region and both towns experienced a significant increase from other areas in the west.

Overall, the average number of work trips in the region more than doubled from 338 trips per week to 724 trips per week in 2012. About two-thirds of the increase is because of the 17-fold increase in work trips between the two towns. The remaining increase is equally because of increased in-bound and out-bound work traffic. The number of trips to and from Ólafsfjörður increased from 222 to 324 per week but the average length of each trip decreased from 162 km to 106 km. The total volume of all work trips to and from Ólafsfjörður therefore declined by about 1.600 km per week, or about 5% of the total volume of work traffic before the tunnels. In contrast, the average length of trips to and from Siglufjörður was more than halved from 349 km to 154 km while the number of trips per week more than tripled from 116 to 400 per week. The total volume of all work trips to and from Siglufjörður therefore increased by about 2.100 km, or more than 50% of the total volume of work traffic before the tunnels. After the tunnel, Siglufjörður

accounts for about 64% of all work travel in the area, slightly above its 60% share in the population of Fjallabyggð.

Table 4 shows the results of multinomial logistic regression models (Pampel, 2000), based on in-home surveys among residents in Ólafsfjörður and Siglufjörður. The first column shows odds of work travel once or a few times per month, the second column once or a few times per week and the third column the odds of daily work travel. Two types of statistical significance are employed. First, a t-test is shown for each coefficient indicating differences from the omitted contrast for each variable. Second, chi-square tests are shown for each predictor across all three outcomes, indicating the probability of differences occurring by chance. Only statistically significant interactions are included in the final model.

The results show that the self-reported number of work trips every month or every week more than doubled after the tunnels. There is a similar overall tendency for an increase in daily work travel, but this effect is not statistically significant once increased work travel by mothers of children under 18 has been taken into account. Residents of Ólafsfjörður are twice as likely to travel out of town to work as the residents of Siglufjörður. The increase in work travel associated with the tunnels appears to apply equally to both towns as the interaction between year of survey and town is not statistically significant for any frequency of work travel. Those who had lived less than five years in the community were not more likely to travel to work. There is furthermore not a significant difference between age groups in this regard.

Table 4
Multinomial logistic regression predictors of self-reported monthly, weekly and daily work trips from Ólafsfjörður and Siglufjörður before and after the Héðinsfjörður tunnels

	Monthly	*Weekly*	*Daily*	*Chi-square*	*df*	*Sign.*
Year of survey						
2012	2.10b	2.13b	1.47	10.66	3	p. < .01
2009 (contrast)						
Town						
Siglufjörður	.43c	.47b	.52b	17.07	3	p. < .001
Ólafsfjörður (contrast)	.					
Gender						
Female	.25c	22c	,36c	39.03	3	p. < .001
Male (contrast)						
Age group						
18-25 year old	1.03	1.24	.90	.16	3	Non-sign.
41-66 year old	1.56	1.38	.62	3.23	3	Non-sign.
26-40 year old (contrast)			---			
Residence in community						
Less than five years	.38	1.79	1.54	4.80	3	Non-sign.
Longer (contrast)						
Education						
University degree	4.59c	4.54c	3.76c	37.58	3	p. < .001
Trade certificate	.84	.73	1.90a	5.35	3	Non-sign.
Other (contrast)						
Family						
Children under 18	.95	1.03	.70	.91	3	Non-sign.
Other (contrast)						
Interactions						
Siglufjörður x 2012	---	---	---	---	---	---
University x 2012	---	---	---	---	---	---
Trade certificate x 2012	---	---	---	---	---	---
Less than 5 years x 2012	---	---	---	---	---	---
Female x 2012	---	---	---	---	---	---
Female x children x 2012	2.41	2.54	4.50b	8.58	3	p. < .05
Other (contrast)						
Likelihood ratio test				*126.0*	*27*	*p. < .001*
Cox & Snell R^2	*.14*					
Nagelkerke R^2	*.18*					
McFadden R^2	*.10*					

a) p. < .05 b) p. < .01 c) p. < .001

The prevalence of monthly and weekly work travel among women in Fjallabyggð is found to be about a quarter of the prevalence for men while daily work travel for women is about one-third of the prevalence for men. There is not a significant overall effect of having children under the age of 18 in the home. The odds of mothers traveling for work are nevertheless significantly increased after the tunnels as shown by the interaction between being female, having children under the age of 18, and year of survey. The increase in mothers traveling to work thus accounts for the increase in out-bound work traffic after the tunnels.

Education emerges as the strongest predictor of traveling for work in this study. Those with a university degree are four to five times as likely to travel outside their home town for work on a monthly, weekly or daily basis. Holding a trade certificate is not significantly associated with monthly or weekly travel but almost doubles the odds of work travel on a daily basis. While this effect is statistically significant, the overall model is not significantly improved by the inclusion of trade certificates. The association between education and work travel does not change significantly after the tunnels, indicating that the increase in work travel applies similarly to all educational groups.

7. Discussion

The daily ebb and flow of work travel has necessitated massive infrastructure investments in most countries, and such investments have in turn had profound effects on urban and regional development (Baum-Snow, 2007, 2010; Garmendia et al., 2011; Haas and Osland, 2014). The results of this study show the potential for strengthening rural labour markets through road infrastructure projects. The Héðinsfjörður tunnels

transformed patterns of work travel between the towns of Ólafsfjörður and Siglufjörður, and between these two towns and the neighbouring fishing town of Dalvík. The massive increase in work travel reflects important changes enabled by the tunnels, including a reorganization of state and municipal services, a growth in tourism and other services and changes in the organization of various industries. More generally, these findings are consistent with the extent of commuting within and between rural communities on both sides of the Atlantic (Green and Meyer, 1997; Grimsrud, 2010; Haas and Osland, 2014; Moss et al., 2004). They are nevertheless in sharp contrast with Lian and Rønnevik's (2010) findings that road infrastructure improvement did not have an impact on work travel among the three thousand inhabitants of Magerøya and the rural mainland in Northern Norway.

It is important to note that tolls may moderate the effects of road infrastructure improvements on local and regional labour markets. Road tolls are widely used in Norway to finance large-scale road infrastructure improvements (McArthur et al., 2013; Odeck and Bråthen, 2002), and at the time of Lian and Rønnevik's (2010) study the toll for using the Magerøya undersea tunnel was equivalent to the previous ferry fare. Such tolls have been found to reduce commuting and contradict the aim of greater territorial cohesion in Norway (McArthur et al., 2013). The Héðinsfjörður tunnels are however free of tolls like most road tunnels in Iceland. This may have facilitated the rapid transformation of work travel after the Héðinsfjörður tunnels, unlike the situation in Magerøya. Further studies should examine the effects of road tolls on work travel in rural areas.

There was no significant change in work travel between Fjallabyggð and the regional centre of Akureyri, despite a substantial and statistically significant redistribution in work travel from Akureyri to Siglufjörður rather than Ólafsfjörður. The tunnels therefore do not seem to have changed the propensity for work travel between the regional centre and the fishing villages towards the north. These results are inconsistent with Lian and Rønnevik's (2010) findings that road infrastructure improvements in Norway increased work traffic in areas within one hour's drive from regional centres. The increase in work traffic from the regional centre of Akureyri towards Siglufjörður is however somewhat consistent with the findings of McArthur et al. (2013) that transportation improvements reducing commuting time from more than two hours to less than an hour primarily increase commuting from a larger towards a smaller rural community. Further research is needed, but it is possible that the distance of 77 km is beyond the tolerance zone for regular commuting, in particular in regions characterized by difficult winter driving conditions. Competition from communities closer to Akureyri may also deter work traffic from the more distant towns, or a regional centre of 18 thousand inhabitants may simply not be large enough to draw workers such distances.

Interestingly, there is clear evidence of increased work travel from the two towns to the region of the national capital of Reykjavík, more than four hours away by car. This is far beyond the established tolerance zone for regular commuting (Cassel et al., 2013; Lian and Rønnevik, 2010). It should however be noted that the less restrictive notion of work traffic employed in this study includes various work-related trips that would not be considered commuting in the strict sense. As Amcoff (2009) has suggested, it is possible that studies focusing on more traditional daily commuting underestimate the extent of

less regular long-distance work travel. A stronger rural labour market may simply call for more travel to the national capital where government offices are generally located, most larger businesses have their headquarters, and residents account for two-thirds of the national market for goods and services.

Road infrastructure improvements that shorten distances and increase the density of employment regions could be expected to lead to a lower overall volume of travel. However, shorter distances tend to lead to more frequent travel and the total volume of commuting may thus remain constant (Haas and Osland, 2014; Limtanakool et al., 2006; Ommeren and Rietveld, 2005; Van Wee et al., 2006). The findings of the current study suggest that the effect of infrastructure improvements on total volume of rural work travel may vary substantially by local conditions. As Ólafsfjörður was already relatively well connected to the nearby town of Dalvík and the regional centre of Akureyri, the additional short-distance option of work travel to Siglufjörður led to a slight decline in total km travelled. In contrast, Siglufjörður was quite isolated prior to the tunnels and the road infrastructure improvements led to a substantial increase in the total volume of travel. This suggests that Ólafsfjörður primarily experienced an adjustment in the direction and destination of work travel while the tunnels released a pent-up demand for both in-bound and out-bound work travel in Siglufjörður.

Improvements in road infrastructure have been found to have contributed to decentralization of urban residence patterns. The development of the highway system after the second world war was a major cause of suburbanization in the United States (Baum-Snow, 2007) and specific megaprojects such as the Øresund bridge between Denmark and Sweden (Knudsen and Rich, 2013) and the Spanish high speed rail link

between Madrid and the provincial centre of Ciudad Real (Garmendia et al. (2011) demonstrate the potential for peripheral growth through new commuting opportunities. Recent in-migrants to rural areas have in turn been found to be much more likely to commute long distances (Champion et al., 2009). In Ólafsfjörður and Siglufjörður, however, the proportion of new residents actually fell as work travel into the towns increased after the Héðinsfjörður tunnels were opened. The probability of work travel did not differ significantly between residents that had moved into the community within the last five years and those who had lived there for more than five years. Further research may determine if large-scale infrastructure improvements may in fact decrease in-migration under certain circumstances as rural employment opportunities may be seized without necessarily moving into rural areas.

Denser and more diverse local labour markets based on extensive work travel can be seen as an alternative to rural out-migration, in particular for women, younger residents and people with greater occupational specialization (Amcoff, 2009; Green, 2004; Sandow, 2008). Unfortunately, the current data do not include information on the occupation of commuters. However, the effects of age and education were not significantly moderated by the opening of the Héðinsfjörður tunnels, suggesting that the different groups experienced a similar increase in work travel after the tunnels. As elsewhere, females continued to be less likely than males to travel for work (Cassel et al., 2013; Crane, 2007; Dobbs, 2007; Haas and Osland, 2014; Maoh and Tang, 2012). However, the Héðinsfjörður tunnels resulted in significantly increased work travel on a daily basis among women with children under the age of eighteen in the household.

The allure of the ‘rural idyll’ notwithstanding, access to relatively stable, diverse and well-paid jobs is fundamental to sustainable rural development. Major infrastructure improvements may indeed increase the density of rural labour markets, expand the reach of regional centres and contribute to the growth of exurban areas surrounding larger cities. However, the results of this study demonstrate the complex and contingent effects of such interventions. Road infrastructure investments aimed at strengthening regional development must be based on a detailed analysis of local conditions, in particular the balance of distances, population density and labour market characteristics.

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