Transport Policy 115 (2022) 164–180

Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

The wider local impacts of new roads: A case study of 10 projects

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ARTICLE INFO

Keywords:
Appraisal
CBA
Local impacts
Two-way road effect
Wider impacts

ABSTRACT

This paper investigates the impacts of road investments in secondary markets, which the authors label wider local impacts. The impacts are studied using four indicators: commuting, population, new firms, and employment. We use the synthetic control method to study the counterfactual problem, namely what would have happened if a given project had not been realised. The method is used to compare municipalities that had been given a new road with municipalities that had not had a new road. The study sample consists of ten road projects that opened for traffic between 2000 and 2010 and the impacts of the projects are examined at municipal level. The results do not provide a clear answer as to whether road projects are a suitable tool for fulfilling political objectives of improving the local economy. Apart from possibly one exception, none of the projects scored positively on all indicators. We identify several examples of significant negative impacts as a result of road investments, and conclude that although the impacts have been positive in many areas, there is no evidence that road investments are generally a potent tool for achieving positive wider local impacts.

1. Introduction

Since the emergence of the modern state system, investments in roads, railways, ports, airports, and other transport infrastructure have been a strategic focus area for governments throughout the world. The establishment of railways transformed the world in the 19th century, and from the early decades of the 20th century, new technology provided an opportunity to intervene in and transform nature and the landscape in a way that gave rise to industrialisation and economic growth which in many ways is still a basis for welfare today. After World War II, automobile ownership increased and in the following decades most countries invested heavily in road networks. The investments in better transport infrastructure led to significantly reduced travel times for people and goods. It is difficult to imagine today's standard of living without the current state of the transport network.

In most developed countries, the welfare effects of road projects are calculated by means of cost-benefit analysis (CBA). CBA is used to calculate social effects by using change in consumer surplus, which is done by assigning monetary values to goods that are normally not traded in markets. CBA is a well-established method for economic appraisal and allows for comparisons of projects and project alternatives using summary measures such as the net present value (NPV) and the benefit-cost ratio (BCR).

Despite the widespread use of CBA, investment decisions are often strongly influenced by other political preferences (Gühneman et al., 2012). In Norway, the use of CBA has traditionally had a limited impact on project selection (Eliasson et al., 2015), even if decision-makers have been found to place an implicit value on the elements of the appraisal such as travel time, reliability and costs (Odeck, 2010). Generally, the NPV is usually higher in projects with high traffic levels and areas where the conditions for growth are favourable. This may be at odds with political aspirations for mitigating spatial economic disparities. Overman (2020) argued that better roads can increase the attractiveness of one area over another and hence exacerbate rather than reduce economic and social disparities. Furthermore, it is widely acknowledged that CBA does not capture everything that may be relevant to society. The method is poor with respect to distributional impacts and the consequences for the environment have little or no effect on value-for-money. The results may give an indication of which policies are desirable from an economic perspective, but decision-makers in most countries usually consider several societal aspects when allocating funds for investment.

Therefore, funds for transport infrastructure have often been regarded as a tool for 'building the country' as a kind of public good to be distributed fairly among regions and taxpayers. Furthermore, many stakeholders hope that better roads and railways will make firms more

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https://doi.org/10.1016/j.tranpol.2021.11.012
Received 2 February 2021; Received in revised form 18 October 2021; Accepted 12 November 2021
Available online 17 November 2021
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productive and consequently deliver economic benefits in excess of the benefits for the users of the new infrastructure. Since the turn of the millennium, considerable research effort has been made to estimate the possible wider economic benefits of improved accessibility. However, transport infrastructure has also been used as a redistributive tool and in the hope of achieving specific objectives such as levelling up economic activity. We label these as *wider local impacts* – 'wider' because the impacts are not fully captured by CBA and 'local' because they are not necessarily additional net benefits.

CBA measures net effects but can mask possible non-desirable distributional effects such as moving economic activity from deprived areas to other areas. An underlying rationale for CBA is the Kaldor–Hicks compensation principle: a policy, programme or project is justifiable in economic terms if the winners could potentially compensate the losers and still be better off. However, there is no requirement or mechanism for such compensation to take place. Therefore, in many cases, the objectives of transport projects may not be to achieve additional net effects at all, but to improve welfare and economic activity in selected areas. Such results are often difficult to measure ex post due to the counterfactual problem.

This paper aims to contribute to the literature on wider impacts of transport infrastructure by investigating whether roads have impacts beyond the direct user effects that are measured by CBA. In a world of increasing regional inequalities, politicians often look for measures that can rebalance the economy, and in this regard transport investment is often considered a powerful tool. However, the empirical evidence for wider local impacts is limited. Ex post evaluations of schemes are generally rare and most of the literature published to date on wider impacts has been on additionality or net wider impacts.

We do not look at net impacts for the whole country or for regions. These can be small and difficult to measure, and it can take a long time before they occur. Instead, we identify indicators for growth, which are of political interest. Such impacts can be positive for the whole country, but there can also be impacts that are significant locally, due to redistribution.

Wider local impacts are important for several reasons. For example, the large government investments in new road and railway projects indicate that there is a need to document the projects' impacts. This is important for the realism of plans and objectives ex ante, and for identifying criteria necessary for projects to succeed. It is also important for public debate, which is often characterised by assumptions and based on weak documentation of the conclusions drawn.

The paper proceeds as follows. In Section 2, we describe different approaches to measuring the quality of projects and how ex ante appraisal may capture the ambitions of different stakeholders. In this section we refer to some previous studies. The data and methodology that we use in our analyses are described in Section 3. In Section 4, we present our results, and in Section 5 we offer some concluding comments.

2. Direct, local, and wider impacts

There are many different reasons for carrying out road projects, and national, regional and local perspectives may matter to decision-makers. Nevertheless, projects are usually selected based on thorough appraisals aimed at providing knowledge of probable user effects and societal impacts. However, no single analytical tool includes everything that may be relevant to all stakeholders. In this section, we present a framework for identifying different effects and impacts. The starting point is first-order user effects estimated by CBA. We discuss its comprehensiveness, what is included and what is not, and the extent to which the results of CBA have been relevant for practical decision making. Thereafter, we focus on the wider local (second order) impacts on communities. We describe how transport projects can have such impacts and the empirical evidence of previous projects. Lastly, we discuss whether or how transport projects can have third-order impacts on firm productivity, on competition, and on the labour market. Such results are normally referred to as wider economic impacts.

Fig. 1 illustrates our framework, which is similar to the one presented by Laird and Venables (2017, p. 3), but with one important difference. Whereas those authors referred to all impacts beyond the direct user effects as 'wider economic impacts', we argue that such impacts can be either additional to the economy or they can be a result of a transfer of economic activity from one area to another. In the latter case, they will not represent an additional benefit to the benefits identified by the CBA and, in our opinion, classing them all as wider economic impacts probably would be wrong, although they may still be of interest to project stakeholders and promoters.

2.1. User effects

CBA is a common method of appraisal in most industrialised countries, but whereas one can often get the impression that CBA is the be-all and end-all of appraisal, in most cases it is one element in a wider framework of appraisal. In Norway, the expected results of large road projects are first appraised through conceptual appraisals in which different conceptual solutions to a problem are assessed in relation to goal achievement and value for money (Volden, 2019). Depending on government approval, further planning is carried out in accordance with the Planning and Building Act. The Norwegian Public Roads Administration (NPRA) meets the requirements of the Act through its method for impact assessment (Statens vegvesen, 2018).

The NPRA's method for impact assessments covers both monetised and non-monetised effects and impacts. The monetised effects are calculated in the CBA, whereas the non-monetised impacts, such as on nature and landscape are assessed using an ordinal scale. The goal achievement of the various alternatives is assessed, before one alternative can be recommended. For selected projects, wider economic impacts (part 3 in Fig. 1) and land use changes may be estimated.

CBA is an important part of impact assessments in Norway and the NPRA uses a lot of resources on modelling and estimating the effects of potential road projects. The range of variables that are included is large, and Norway along with other countries in Northern and Western Europe are among the countries with the widest coverage in its appraisal framework (Holmen, 2020). Despite this, several studies have documented that value for money has had little or no impact on project selection (Eliasson et al., 2015). Holmen (2020, p. 464) asserted that the process for road project selection in Norway has been characterised by 'regional horse-trading, the availability of strong state finances and extensive waste of resources' and that 'Norway appears to be one of the countries that uncritically wastes money on malinvestment in road construction projects with low net benefits'.

The lack of selection efficiency in Norwegian road planning have probably been caused by different factors. The challenging topography and low population density compared with most other European countries inevitably results in a low share of projects having a positive net present value. Halse and Fridstrøm (2019) showed that geographical factors may explain a substantial part of the variation in the benefit-cost ratio. Another factor in the lack of selection efficiency is the prominent centre-periphery dimension in Norwegian politics, which has led to generous policies for the promotion of social cohesion and regional development (Stein et al., 2019). CBA focuses on national impacts and a positive net present value may disguise the fact that a scheme can create winners and losers. For this reason, Norwegian decision-makers have been more likely to allocate funds based on a desire to improve the well-being of selected areas than decision-makers in countries that put more emphasis on CBA results. As a result, knowledge of schemes' impacts on specific objectives and local impacts may be more relevant than refinement of CBA-based methodologies that nevertheless are of limited interest to policymakers.

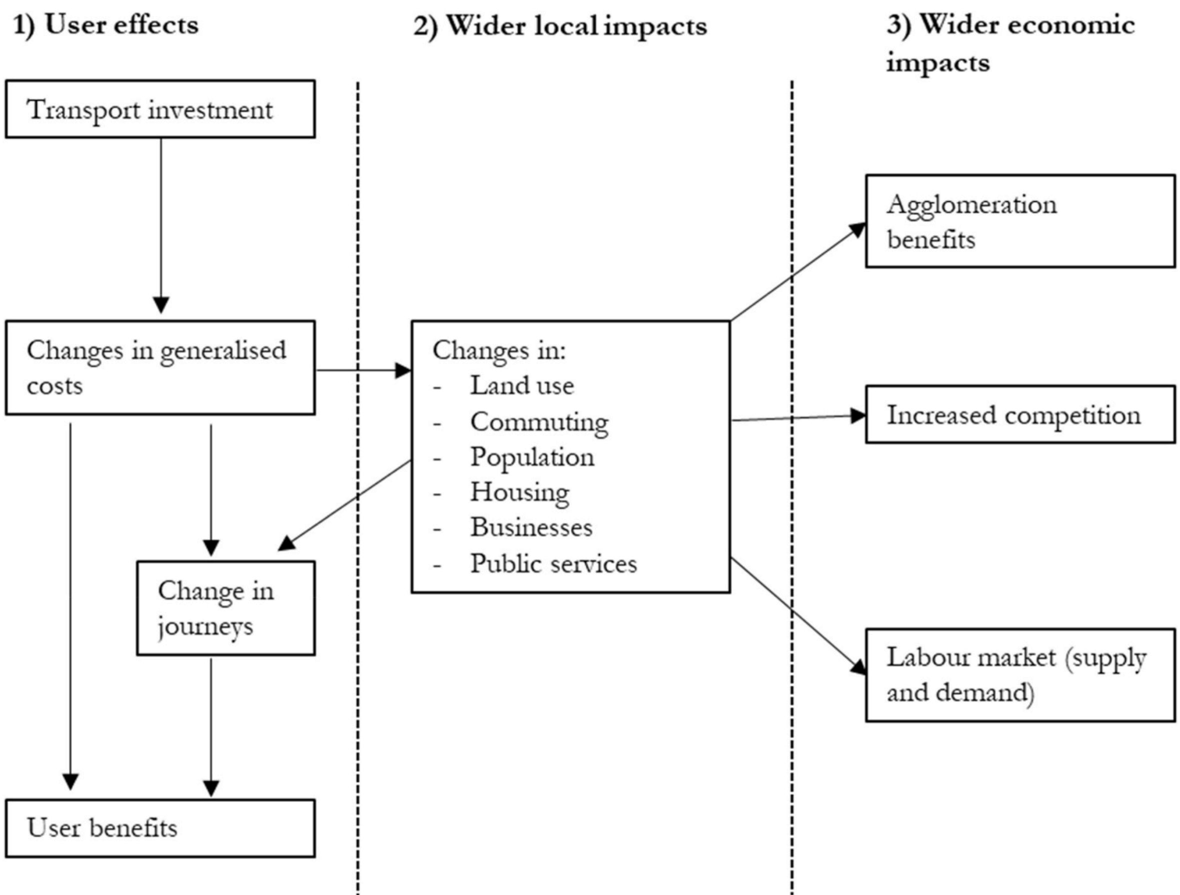

Fig. 1. The direct effects and wider impacts of transport investment (based on Laird and Venables, 2017 p. 3).

2.2. Wider local impacts

All road projects have objectives. These are often travel time savings, improved safety and other effects that are valued in the CBA, but many projects have ambitions that are not necessarily covered by the economic appraisal. Decision-makers often have aspirations such as maintaining or increasing the population in selected areas, giving communities access to better public services, or promoting increased economic activity in areas with particular challenges. This has especially been the case in Norway, where much of the economic activity takes places in industries such as oil and gas, fishing and aquaculture, and shipping and shipbuilding. These are industries where the resources are fixed in location and where access to national and international markets can be crucial. There is also considerable commuting from more densely populated areas to rural municipalities with such industries, which often can provide well paid jobs, but which struggle to find skilled labour locally. Various governments have therefore invested in infrastructure in peripheral regions, and road projects have often been aimed at realising secondary impacts outside the transport market. Achieving such objectives can lead to realisation of wider economic benefits, but not automatically. The case for change or a project's strategic case may often be about gross impacts for a selected area rather than net impacts for the whole economy. Diverting firms and economic activity from one area to another is often the intention of government policy.

Wider local impacts could be negative. The 1999 SACTRA report "Transport and the Economy" (Standing Advisory Committee on Trunk Road Assessment, 1999) recognised that road projects can have complicated spatial impacts and that the result in some areas may be the opposite of intensions. Improved accessibility between two regions may benefit prosperous areas rather than the poor areas targeted by the scheme. Thus, focusing on nation-level results, such as CBA results, may mask undesirable local impacts. This is often referred to as the two-way road effect.

Empirical evidence of the two-way road effect remains limited. In a study of the impact of the M25 around London, Linneker and Spence (1996) showed that there may be a negative relationship between accessibility and employment change. The authors suggested that improved accessibility may have two types of impacts: it may enable local firms to expand their markets, and potentially increase employment; it may facilitate expansion in the reverse direction, as stronger external firms may penetrate the area with improved accessibility. Gibbons et al. (2019) found more encouraging results in their study of the impact of new road infrastructure on employment and labour productivity. Using data from 31 schemes involving new constructions from 1998 to 2007 and with a total length of 318 km, they found strong evidence that the road improvements had increased both the number of new firms and employment. However, Gibbons et al. could not verify whether these impacts were additional to the economy as a whole or whether they were a result of a transfer from other areas. In the latter case, there could be areas that have become worse off because of the new infrastructure. In other words, the link between better roads and positive local impacts may not be clear cut.

The two-way road effect illustrates the goal conflict in transport planning: the achievement of one goal may come at the expense of another goal. For example, the goal of increased population in peripheral areas and increased commuting can counteract agglomeration that is considered the main source of productivity impacts. Commuting over long distances may also conflict with CO_2 emission targets. Improved accessibility and reducing generalised costs can increase long-distance travel and urban sprawl, which in turn can have a range of negative impacts such as increasing congestion and car reliance and reduction in the modal share of public transport and active travel modes (De Vos and

Witlox, 2013). For both agglomeration and general resource utilisation, it can be more efficient if people move from sparsely populated areas to cities rather than in the opposite direction. However, this may not necessarily be an unambiguous result. Price pressure and capacity constraints may suggest that there are negative counterforces in the cities, and the COVID-19 pandemic further illustrated the vulnerability of densely populated areas.

For decision-makers who desire to help disadvantaged areas or who have ambitions for impacts that are not covered by the output metrics of CBA, it is problematic that these impacts are rarely documented. The traditional view has been that estimating direct user effects with a reasonable degree of accuracy ex ante is difficult enough. To provide meaningful estimates of second or third order impacts would be extremely complicated. However, there is a lack of ex post impact assessments or evaluations that could guide future appraisals (International Transport Forum, 2017). For this reason, in this paper we seek to improve the balance between ex ante assumptions and ex post knowledge.

2.3. Wider economic impacts

The spatial implications of transport infrastructure have always been recognised, and historically the impact of roads, railways, ports, and other infrastructure have probably been crucial to today's level of economic activity through improving accessibility between resources, firms, and markets. Whereas earlier academic literature on productivity impacts focused on the macro-level, since the early 2000s there has been increasing interest in the impact of transport projects on agglomeration and firm-level productivity. Since the publication of Graham's study of the possible density effects of Crossrail in London (Graham, 2007), the estimation of wider economic impacts has been incorporated in the UK's methodology for the appraisal of transport projects (Department for Transport, 2018). Wider economic impacts are those not captured in standard CBA, relating to returns to scale, agglomeration, thickening of labour markets, and reductions in market power (International Transport Forum, 2008). An increasing number of countries now include various wider impacts in their CBAs, but there is no international consensus on how and which of the impacts that should be included in the analyses (Wangsness et al., 2017).

The theoretical foundation of wider impacts is that improved accessibility will bring firms and labour markets closer to each other and thereby improve conditions for sharing knowledge and learning, and to match the skills of employees more closely to those of potential employers. A number of studies (mostly ex ante) (e.g., Graham and Gibbons, 2019) have estimated that this can improve the productivity of firms and thereby increase economic welfare nationwide. In addition, transport projects' ability to deliver economies of scale through increased competition between firms or reorganising public services, as well as increased labour force participation, is usually classed among net wider economic impacts, cf. Fig. 1.

The increased attention paid to wider economic impacts has been useful for scheme promoters with low confidence in traditional CBA and to those convinced that schemes that are highly desired locally but have negative value for money will have substantial benefits 'outside the CBA'. The additional benefits to Crossrail estimated by Graham (2007) were instrumental in the Department for Transport's subsequent approval of the scheme (Vickerman, 2013). In Norway, the NPRA has made considerable efforts to estimate potential positive impacts from planned road projects. Tveter (2020) reviewed 55 of these ex ante estimations, most of which based on agglomeration impacts, and found huge variations. The estimated additional benefits as a percentage of user benefits varied from close to 0 per cent to over 200 per cent, even in the same projects. Tveter's overview illustrated that results of ex ante estimations are sensitive to model specifications.

In addition to the huge uncertainties about ex ante estimates, the evidence of wider economic impacts is complicated in other ways. For example, agglomeration is difficult to observe. Tveter and Laird (2018) argued that the impacts may take 10–15 years to materialise in full and may be spread over a wide geographical area. If nationwide productivity increases by 1–2 per cent annually, the impacts of agglomeration may be extremely difficult to isolate. As a result, few ex post studies have convincingly verified ex ante estimates and/or documented the impacts of past schemes. Holmen (2020) studied the productivity impulses from substantial road improvements in the southern part of Norway but found only weak impulses through commuting and possibly through industrial restructuring. Based on his own results and a review of the scholarly literature, Holmen concluded that the empirical evidence of productivity impulses from road investment in rural areas was weak. Melia (2018) surveyed four meta-analyses covering 223 studies and concluded that the claims about the national economic benefits of transport investment were not supported by underlying evidence. Instead, the author (ibid.) asserted that reports estimating wider economic impacts were based on personal opinion rather than scientific evidence.

Thus, despite recent developments in methodology and spending priorities aimed at boosting economic growth through building new transport infrastructure, the link between the two remains controversial. The estimation of wider economic impacts ex post is uncertain, and their size may be unobservable at local level. In reality, it is possible that the local results are of most interest to policymakers. Such impacts are examined further in the remaining part of this paper.

3. Data and methodology

In this section, we outline the empirical strategy for estimating the wider local impacts of a set of completed road projects. To link objectives and estimated impacts, we need quantifiable indicators as well as a reliable estimation strategy for measuring each change of direction that an indicator has taken since the road opened.

3.1. Data relating to indicators of wider local impacts

To measure wider local impacts, researchers depend on measurable indicators. The analyses should be transparent and replicable (i.e., they should be based on publicly available data). Furthermore, the indicators should be comparable over time with available statistics. Some typical formulations of objectives in Norwegian road projects with associated indicators are listed in Table 1.

The first two objectives listed in Table 1 relate to widening of the labour market and linking regions together by increasing accessibility. It is widely assumed that regions where transport projects link areas with firms that have different types of structure together will have a more stable and stronger development over time compared with other regions. Larger labour markets tend to have stronger employment growth than smaller ones, partly due to the industrial structure becoming more favourable. This explanation fits well with expectations of increased resilience with increased labour market size and reduced economic sensitivity due to a heterogeneous business sector. However, regional integration declines with increasing travel distance. Projects that do not reduce the travel time between places of residence and work to the time people are willing to spend on daily commuting (normally considered a maximum of 45–75 min each way), probably have limited regional consequences.

Table 1
Data relating to indicators of wider local impacts.

No.	Objective	Indicator
1	Expand the labour market/ease the recruitment of labour	Commuting
2	Link regions together/coherent housing and labour market	
3	Growth in settlement/counteract depopulation	Population
4	Growth in firms	New firms
5	Growth in employment/work participation	Employment

A widening of the labour market can be measured by the extent of commuting. By looking at commuting between municipalities, we can identify cases where commuting increases in one municipality but decreases in another. Figures for commuting are readily available from Statistics Norway, both at municipal level and with continuous time series (Statistics Norway, 2020a).

The third objective is linked to the ambition to maintain the main features of the settlement pattern, which has been repeated in several editions of the National Transport Plan. Even though the proportion of the population living in cities and towns has increased in recent years, Norwegian decision-makers are still making strong efforts to maintain the rural population. According to the most recent data, 18 per cent of the population live outside urban settlements (Statistics Norway, 2020b). Regions with large populations have a stronger appeal to both individuals and companies than regions with small populations. Higher population growth can stimulate local demand and increase the number of jobs. Growth in settlement and counteracting depopulation can be measured by population in municipalities based on data from Statistics Norway.

The fourth objective concerns the impact on the business sector as measured by new firms. This measures the change in innovation and entrepreneurship in an area, which can create new jobs. In this paper, we only include new firms with more than five employees, to ensure that we measure new jobs and not just the scope of entrepreneurial activity.

The fifth objective of increased employment measures the impact on both existing and new companies. This objective seeks to capture how existing firms are affected by better infrastructure. Here, there is a certain overlap between existing firms and new firms because the number of employees includes both types.

3.2. Methodology

We use the synthetic control method to deal with the counterfactual problem, i.e., what would have happened if the project had not been realised. The method was first used to examine the economic impact of the terrorist conflict in the Basque Country on the development of GDP from 1970 to 1990 (Abadie and Gardeazabal, 2003). The principle of the method is to create a synthetic version of the counterfactual outcome for the treated unit to be used as a control unit. The synthetic control unit should imitate the counterfactual development in the outcome variable.

It is often difficult to find a municipality that is sufficiently similar to the municipality where a project was implemented. Ideally, the control municipality should be equal to the treated municipality in all possible ways except that the treated municipality has gained improved accessibility through a road project. If the requirement for a control municipality is set that high, it will be impossible for practical purposes to find an adequate control municipality. A more realistic approach is to require that the control municipality has a similar development to the treated municipality for the indicator in the period before the opening of the project. However, it can be demanding to find a municipality that meets this criterion. One solution to this problem is to create a control municipality from different municipalities so that the composite (synthetic) municipality is a satisfactory control unit. The synthetic control method makes the selection based on objective criteria and presents the result in a transparent way, as it is easy to see which and how different municipalities are part of the synthetic control municipality.

In this study, we estimate what would have happened to the indicator Y_{it} if the project had not been built. In Equation (1), Y denotes any of the indicators listed in Table 1, i denotes a municipality, and t denotes a year. The impact of the project is then the difference between the actual (observed) and the counterfactual (not observed) levels of this indicator. We denote the actual level of the indicator as Y_{1t}, where the subscript i is substituted by 1. The counterfactual state of the indicator is denoted as Y_{1t}^{CF}. In the years after the opening of the project on the indicator can be written as:

$$\alpha_t = Y_{1t} - Y_{1t}^{CF} \tag{1}$$

The solution offered by the synthetic control method is to substitute Y_{it}^{CF} with a control group that consists of different units. In addition, the control unit should be a weighted average of similar municipalities, where there was no infrastructure improvement during the period in question. We refer to all the potential control municipalities as the donor group. The donor group consists of J municipalities (where the first is the treatment municipality). The weight for the control municipality ω_j is chosen so that the synthetic control municipality to the greatest possible extent matches the development in the treatment municipality before the opening year.

The impact of the transport measure in the periods after the opening year is given by:

$$\alpha_t = Y_{1t} - Y_{1t}^{CF} = Y_{1t} - \sum_{j=2}^{J} \omega_j \times Y_{jt} \tag{2}$$

In the presentation of the estimation results, we use the treatment gap after the opening year (t^*) for ease of comparison:

$$gap_{t-t^*} = 100 \times \frac{\alpha_{t-t^*}}{Y_{1t-t^*}^{CF}} \tag{3}$$

This is the percentage difference between the treated unit and the control unit (hereafter referred to as the gap), where the period is normalised to the opening year.

In our main analysis, we use a trimmed pool where we only include municipalities that differ less than 30 per cent from the treated unit. The synthetic control is thereafter selected from this trimmed donor pool. A possible problem of selecting control units from other areas, however, is that there could be region specific differences. To address this concern, we also execute an analysis where only municipalities from the same county (in-county) is included in the donor pool.

The synthetic controls are constructed to replicate the trend for the different indicators. Similarity in the business cycle trends is therefore implicit one of the criterions for the construction of the control units. Given that the synthetic controls represent the counterfactual outcome, the treated unit and the control will share the business cycle trends in the whole analysis period.

3.3. The projects

We use a sample of ten road projects. The selection of projects was based on the following criteria:

- Relatively large travel time savings or significant standard increase compared with the situation prior to the project.
- Project objectives beyond direct user effects.
- Opening year between 2000 and 2015.
- Possible to isolate the impacts at municipality level.

Based on this, we end up with the projects in Table 2.

Table 2 shows that the projects' traffic levels varied substantially. Most of the roads had very low traffic levels before the opening ('AADT before' refers to the average annual daily traffic in the last full year of traffic before road improvement) of the projects and the levels have remained low in half of them because they are in rural areas, albeit in areas where the authorities had ambitions that the new roads would create positive impacts. Most of the projects have contributed to significantly reduced travel times, especially the fixed links that replaced former ferry services with limited frequency of services and hours of operation. The average annual traffic growth rate after opening has been substantial.

Road tolls have been used to finance roads in Norway since the 1930s and accelerated particularly from the late 1980s. Tolls provide extra funding that are used to finance much desired infrastructure, but for new

Table 2
The sample of projects.

No.	Project	Municipality*	Opening year	Type of project	Time saving (min.)	AADT** before the project opened	AADT 2021 (average annual growth rate)
1	Fv653 Eiksund-sambandet	A. Ulstein B. Volda	2008	Fixed link (tunnel)	20–40	850	3,000 (10%)
2	Fv64 Atlanterhavs-tunnelen	A. Averøy B. Kristiansud	2009	Fixed link (tunnel)	10–30	800	2,500 (10%)
3	E18 Grimstad-Kristiansand	A. Grimstad B. Kristiansand C. Lillesand	2009	Road improvement (conversion to dual carriageway[a])	15	9-23,000	15-26,000 (2%)
4	Fv519 Finnfast	A. Finnøy	2009	Fixed link (tunnel)	15–30	350	1,300 (12%)
5	Fv107 Jondals-tunnelen	A. Kvinnherad B. Ullensvang	2012	Road improvement (new route)	60	300	700 (10%)
6	E39 Kvivsvegen	A. Stryn B. Volda	2012	Road improvement (new route)	45–60	1200	2,000 (6%)
7	Fv609 Dalsfjord-sambandet	A. Askvoll	2013	Fixed link (bridge)	25–40	50	800 (41%)
8	Fv616 Bremanger-sambandet 2	A. Bremanger	2013	Road improvement (new route)	45	n/a	500
9	E39 Klett-Bårdshaug	A. Melhus B. Orkdal C. Skaun	2005	Road improvement (new route)	5	5-8000	10-12,000 (3%)
10	Rv7 Sokna-Ørgenvika	A. Flå B. Krødsherad C. Ringerike	2014	Road improvement (new route)	15	3500	5,000 (5%)

Note: *The municipalities are ordered alphabetically. The letters are used to identify the municipalities in Section 4.
** Average annual daily traffic.
[a] A dual carriageway (British English) or divided highway (American English) is a class of highway with carriageways for traffic travelling in opposite directions separated by a central reservation (Wikipedia, 2021). Conversion from a single carriageway (undivided highway) normally improves road standard, speed and traffic safety.

projects tolls imply that the reduction in generalised costs will be smaller than it would be had the road been free at the point of use because traffic is lower than what is optimal from an economic perspective (Odeck, 2017; Welde et al., 2020). Toll financing in Norway is project based in that tolls are used to finance individual projects. A non-profit toll company is responsible for taking up loans for construction and for running the toll collection systems in the project's operational phase. Once the loans needed to finance the road construction are paid off, the tolls are removed. Today, most large road projects are financed partly by tolls in addition to government grants. Table 3 shows the toll levels for ordinary passenger vehicles (vehicles exceeding 3.5 tonnes are usually charged 2–3 times that rate) in the projects that were partly financed by tolls.

In some of the projects, the toll levels were relatively high which reflect the reduction in generalised costs and the removal of the inconvenience of having to rely on a ferry service that only operated parts of the day.

The removal of tolls in our estimation results in a reduction in generalised costs that comes in addition to the benefit of the infrastructure project. Most of our cases either still have tolls or the tolls were removed in the last years of our estimation period. It is only for two of the projects (no. 1 and 9) where there is enough time for the toll to result in additional benefits. For these two projects we will have this in mind when interpreting the results.

As road projects may influence large areas and as impacts can be both positive and negative, we look at impacts for 20 different municipalities with a combined population of about 270,000 inhabitants.

Table 3
Tolls for vehicles <3.5 tonnes.

No.	Project	Tolls in the opening year (EUR)	Tolls removed (year)
1	Fv653 Eiksundsambandet	7.3	2014
2	Fv64 Atlanterhavstunnelen	7.2	2020
3	E18 Grimstad-Kristiansand	2.9	2018
4	Fv519 Finnfast	19.2	2021
5	Fv107 Jondalstunnelen	9.1	2020
6	E39 Kvivsvegen	0	–
7	Fv609 Dalsfjordsambandet	0	–
8	Fv616 Bremangersambandet 2	0	–
9	E39 Klett-Bårdshaug	1.4	2016
10	Rv7 Sokna-Ørgenvika	6.0	–

3.4. The synthetic controls and the donor pools

The donor pool differs in each of the estimations. Our data set included 353 municipalities, but each donor pool included only a subset of these. In the main estimations, we only include units which deviates less than 30 per cent from the treated unit. After this operation, the donor pool includes typically 50 units (see Table B1, in the appendix). In one case is the donor pool rather small (case 3B). The reason is that this unit is a large municipality with few municipalities with a similar size. Between the different indicators there are no substantial difference between the size of the donor pools. The difference is typically 10–20 per cent.

As a sensitivity check, we also provide an analysis where we the donor pools included only the municipalities in the same county. The donor pools are therefore identical for the different indicators for the same projects. In this case the number of units in the donor pool is lower than in the main estimates, with an average of around 34 units.

The weights, from the optimization procedure described in Section 3.2, is reported in Table B2–B5. The tables included the name and weight for the units with the largest weights in the construction of the synthetic control. The units with small weight are summed and represented as "Other" at the end of the list of controls. Each list of controls is manually checked for the inclusion of municipalities with known changes in the transport system or other changes.

4. Results

In this section we first present descriptive statistics for the changes in the indicators that we use before we turn to the results of the synthetic control estimation.

4.1. Descriptive statistics

Table 4 presents the impacts on population, new firms, employment, and commuting in the treated municipalities. For each of the variables, descriptive statistics are shown for five years before the opening of the project, the opening year, and five years after the opening of the project.

Table 4
Descriptive statistics for the indicators.

Indicator	Mean	Median	Min.	Max	St. dev.
Population					
5 years before opening	13,902	8,952	1011	90,189	19,834
Opening	14,528	9,329	1033	96,330	21,186
5 years after opening	15,358	10,106	1052	103,291	22,702
Employment					
5 years before opening	6,280	3,696	407	47,365	10,751
Opening	7,151	4,123	456	55,452	12,226
5 years after opening	7,483	4,590	473	58,565	12,909
New firms					
5 years before opening	8	4	0	67	16
Opening	11	8	1	86	18
5 years after opening	11	5	0	83	19
Commuting					
5 years before opening	1,562	827	66	13,663	3,060
Opening	1,895	1,043	99	17,355	3,761
5 years after opening	2,108	1,212	112	18,916	4,098

Notes: All data are from Statistics Norway (https://www.ssb.no/en/). Population is the number of registered persons in a municipality on 1st of January in a given year. Employment is the registered workers in a municipality by place of work. New firms are the number of registered new firms per year, with more than five workers. Commuting is the number of workers registered with place of living in one municipality but who work in another.

The population in the municipalities is on average 14–15,000 persons, which is close to the Norwegian average. The population increased in most municipalities after project opening, but the growth rate is not very different from the growth before the opening (both are about 1 per cent).

The employment figures show the same trends. On average, there are just over 7,000 employees in the municipalities (half of the total population). There is an increase in the numbers of employees both before and after the opening year, but also some cases of decline in employee numbers.

The number of new firms varies between municipalities, as can be seen when the mean and the standard deviation are compared. On average, 11 new firms were established per year in the project opening year and five years after opening. For some municipalities, only one firm was established, but two municipalities have more than 80 new firms per year. A problem with this indicator is that it varies considerably and is to a much greater extent exposed to coincidences and general economic trends than are the other three indicators.

The number of commuters in the project opening year was almost 1,900 on average. If we compare these with the employment figures, this means that about one in four employees commuted to work. Here, too, we see an increase both before and after the project opening year. The variation is also significant and in line with the employment figures, with a standard deviation that is twice as high as the mean.

Descriptive statistics gives an overview of the main features of the data, but caution should be exercised when drawing conclusions based on differences in growth before and after the opening of the projects. First, there may be random annual variations. If, for example, the number of new firms happened to be low in the opening year, it would not take much for the number to be higher five years later. This uncertainty is greatest for small municipalities. Second, there may also be overall trends that apply to the whole economy, which would explain the difference in growth rates. Third, and finally, there may be region-specific impacts that come into play. To take these conditions into account, in the next section we present an analysis in which the impacts for the treatment municipalities are compared with a control group that shares important characteristics with the treatment municipality.

4.2. Results of the synthetic control estimation

4.2.1. Commuting

Better roads normally lead to more traffic by giving people access to a larger labour market. However, how large this impact is in the form of commuting can vary in relation to the type of project, the reduction in travel time, and whether the project increases accessibility to an urban area.

All the new roads in this study have resulted in considerable increases in traffic levels, especially projects where tunnels and bridges have replaced ferry services (see Table 2). This is consistent with previous studies of such projects. In a study of 38 fixed link projects, Welde et al. (2019) found that the traffic increase from ferry to fixed link was, on average, 116 per cent, and that the mean annual traffic growth rate thereafter was 5 per cent. To a certain extent, traffic mirrors economic activity, but to equate more traffic with positive local economic impacts is too simplistic. Commuting is therefore often used as an indicator of whether local residents have gotten access to better paid jobs or if local firms have attracted employees from outside.

Fig. 2 shows the estimated commuting gap (as defined in Eq. (3)) for our ten projects, measured as the percentage difference between commuting in the treated municipalities and the synthetic control counterparts. The vertical dashed lines indicate the opening year of the project, which is normalised to zero, and the thick black line shows the zero line of each graph. The other lines display the commuting gap in per cent. If the lines are above the zero line, the commuting is higher for the treated municipality than for its synthetic control unit. For the projects where the impact is estimated for several municipalities, the lines are different. Using the numbering from Table 2, the first municipality is shown as a continuous line, the second with a dashed line, and the third with line of shorter dashes.

Commuting impacts are identified for four of the projects (1, 2, 7, and 9). For the first of these projects (2), the impacts arise in the small municipality that is connected to the larger one. For the second of the projects with a visible result (7) the impact is clear, with an almost instant jump in commuting after the opening year, whereas the impact for the two other municipalities is negligible. Also, in this case, impacts arise for the small units that are connected to the larger ones. For the fourth project (9), there is a commuting impact for one of the municipalities. From a closer inspection of the graph, we see a positive commuting gap for municipality 9C (short, dashed line). However, as the gap first widens almost ten years after opening, it is not credible that it is a causal result of the road improvement. Moreover, the gap disappears, when restricting the donor pool to within-county municipalities. For the last project with a commuting impact (1), the impact varies substantially. There is a growing trend the first years but falls sharply between 2016 and 2018. It then increases again in the last available year 2019. This development is not found in the control municipality and the probable reason is that we do not address the special industry structure in the area, in which specialises in the maritime industry. However, the impact seems clearer in the work by Tveter (2018), who took a more thorough approach to studying commuting and was able to address the industry component.

For one of the projects (4), there are signs of a decrease in commuting. However, this decrease is not present in the robustness

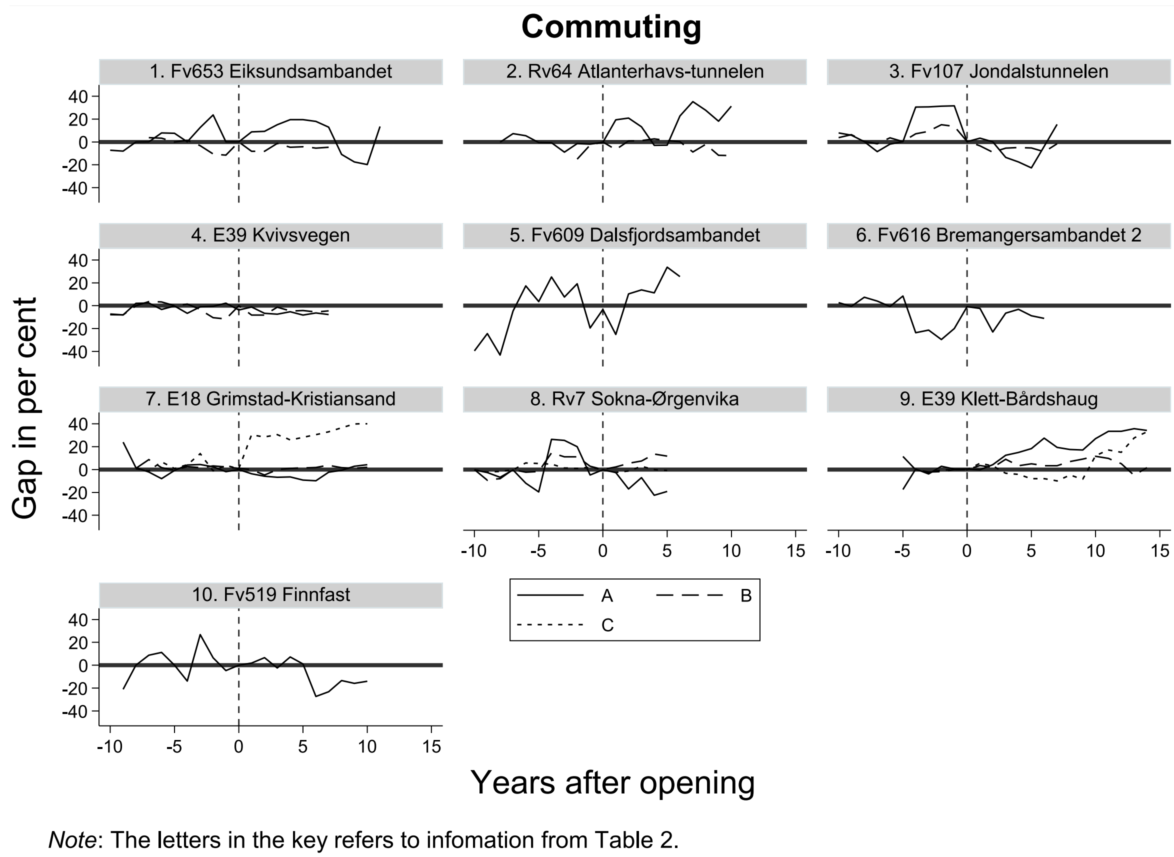

Fig. 2. Commuting gap between the treated municipality and the synthetic control by project. Project opening year = 0.

analysis with control units restricted to the same county (see Figure A1 in the Appendix). Therefore, this decrease in commuting is interpreted as a random variation, which cannot be attributed to the road project.

4.2.2. *Population*

The population of Norway is growing, but the growth is unevenly distributed. The cities and their surrounding areas have experienced strong population growth and probably will continue to do so. By contrast, most rural areas have struggled to maintain their population levels. Many of them hope that better roads can lead to a reversal of a negative population trend.

Fig. 3 shows estimated population impacts. The solid lines show the percentage difference between the each of the treated municipalities relative to the synthetic control. For ease of comparison, the period is shown relative to the opening year. The vertical dashed line shows the opening year of the project, which is set to zero. The x-axis displays the years before and after the opening year.

Fig. 3 shows visible increases in population after the opening year for four of the projects (1, 7, 9, and 10). There are signs of a negative impact on population as a consequence of two projects (2 and 6). For project 2, we interpret this as a random variation. Similar to the development for employment, we see that the gap is close to zero from 2009 until 2015, while the impact seems to start around 2016 (i.e., seven years after the opening of the project).

Most of the projects with a visible population effect are in the proximity of city-like areas. The impacts are not significant for the rural projects.

4.2.3. *New firms*

Economic growth is closely linked to new firms. In recent years, there has been a strong focus on the need for restructuring of firms and for new firms, especially in light of lower growth in the oil industry and the 'Green Deal'.

Fig. 4 shows the impact on firm start-up (new firms). Three of the ten projects (7, 9, and 10) resulted in new firms. For the first of these (7), the impact is visible for the unit where there were impacts on commuting and population. The municipality with project 7 is also connected with relatively larger employment areas. For the second project (9), the impact is visible for the same unit where there were impacts on the population. For the third project (10), the impact is visible but only after more than five years. There is an initial drop in new firms immediately after the opening of the project. There, the fit between the synthetic control and the treated unit varies in the pre-treatment period. Although this result is uncertain, we interpret it as being a cause of the project. The impact is also visible when restricting the donor pool to select within-county controls when constructing the synthetic control.

Impacts on firm start-ups build up slowly. For the impacts that occur for the two projects (4 and 8), we see that it takes time before the positive results occur; in both cases, it seems to take about five years. This means that an evaluation of the projects too early can mean that the impact is not captured. Any evaluation of impact on firms should therefore use at least a time window of five years after project opening.

Negative impacts on new firms are present for two projects (4 and 8). The impacts for the two other projects (2 and 3) that are negative are not present when using within county controls and are therefore regarded as

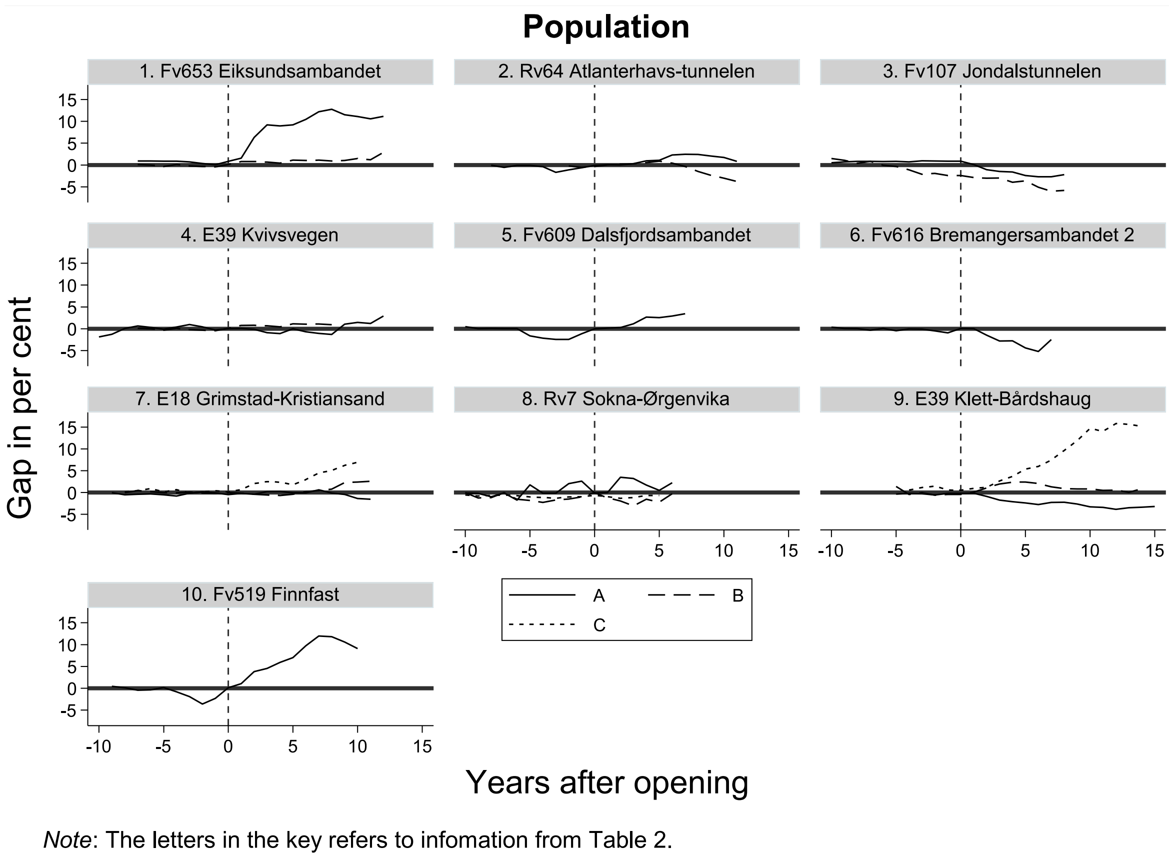

Fig. 3. Population gap between the treated municipality and the synthetic control by project. Project opening year = 0.

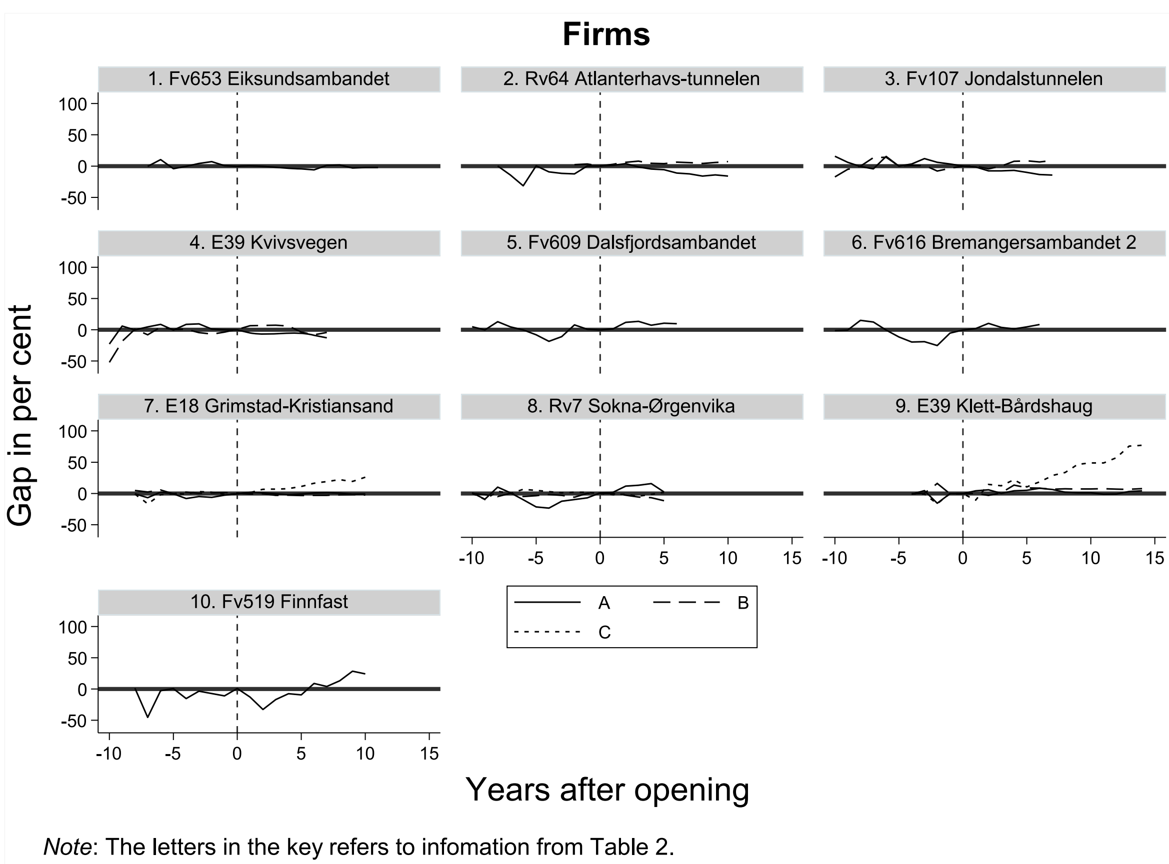

Fig. 4. New firms gap between treated municipality and the synthetic control by project. Opening year = 0.

non-robust results and interpreted as random errors.

The result from this analysis is, however, more uncertain than the analysis for the other indicators, because the number of established firms each year is low. For some of the cases, there is a tendency for a negative impact. The size of the impact is, however, marginal and together with the above-mentioned uncertainty not enough to be interpreted as evidence of the two-way road effect.

4.2.4. Employment

Although the number of new firms may say something about entrepreneurship and the pace of innovation, the impact on existing firms is better measured by looking at the number of employees (by workplace) in the existing firms.

Fig. 5 shows a visible employment impact for three of the ten projects (1, 7, and 9). For the first project (1), this closely mirrors the commuting impact, with a growth in the first years and thereafter a humped-shaped pattern. In line with the above discussion, the impact on employment is regarded as a causal effect of the transport improvement. In the second project (7), the impact closely follows the commuting impacts. The same pattern is visible for the last project (9).

Negative trends are visible for three projects (2, 3, and 4). However, these are not present in the alternative calculation, in which the control group is limited to being within the county or the impacts only appear suddenly, many years after the opening of the project, and are thus likely to be connected to the project.

We note that the impact on employment in existing companies is absent for project 10, while it appears to be visible for new firms.

4.3. Summary of the impacts of new and improved roads

Table 5 provides a summary of the results.

Although better roads affect the cost of commuting, we find few positive impacts on this indicator than expected, even if reductions in travel times have been large. Traffic levels have increased considerably and as most of the roads in our sample have few or no realistic alternative routes, this is an indication that the roads have led to induced demand that would not have occurred without the improvement of the roads. Despite this, there is only a few cases where we can document that this traffic is a result of increased economic activity through commuting. With a view to strengthening the labour market, few projects achieve commuting impacts. This may indicate that the labour market is relatively static, especially in the short term. In addition, more than half of the projects in the sample were partly financed by road tolls, which could increase the cost of commuting significantly. Thus, financing projects with high tolls can weaken the objective of regional integration, which often was one of the reasons why the projects came on the agenda in the first place (Welde et al., 2020). However, tolls have now been removed in all but one of the projects. It is not unlikely that commuting will increase in the future.

The impact on population varies. As Tveter et al. (2017) showed, the result is greatest for projects near cities or regional centres, but even in such areas the results are not unambiguous. It seems that the population only increases in smaller municipalities that are linked to a larger municipality. In our study, we see examples of the population decreasing in the largest municipalities and increasing in the smaller municipalities. That is a sign that first and foremost urban sprawl is taking place.

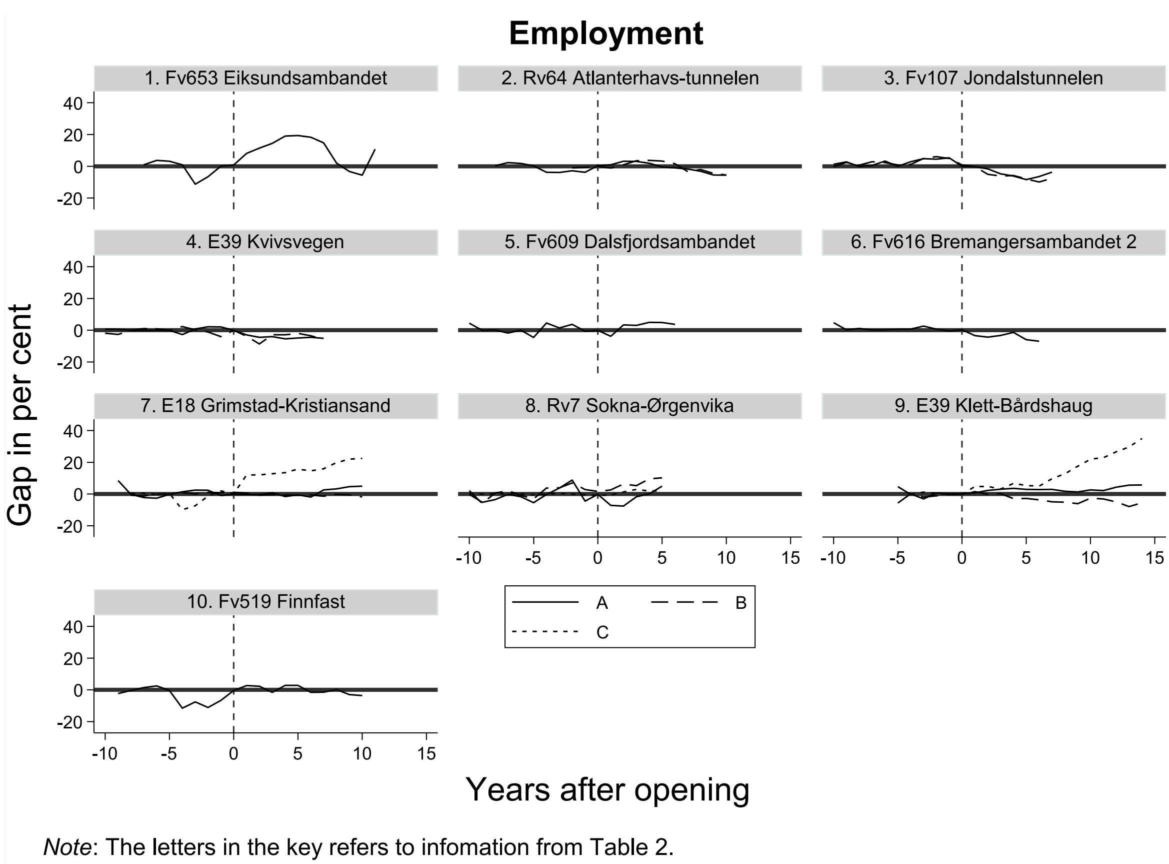

Fig. 5. Employment gap between treated municipality and the synthetic control by project. Opening year = 0.

Table 5
Summary of impacts.

Nr	Project	Municipalities	Commuting	Population	New firms	Employment
1	Fv653 Eiksundsambandet	A. Ulstein	* [green]	* [green]	* [yellow]	* [green]
		B. Volda	[yellow]	[yellow]	[yellow]	[yellow]
2	Fv64 Atlanterhavstunnelen	A. Averøy	* [green]	* [yellow]	* [yellow]	* [yellow]
		A. Kristiansund	* [yellow]	* [yellow]	* [yellow]	* [yellow]
3	E18 Grimstad-Kristiansand	A.Grimstad	* [yellow]	* [yellow]	* [yellow]	* [yellow]
		B. Lillesand	* [green]	* [green]	* [yellow]	* [green]
		C. Kristiansand	* [yellow]	* [yellow]	* [yellow]	* [yellow]
4	Fv519 Finnfast	A. Finnøy	* [yellow]	* [green]	* [green]	* [yellow]
5	Fv107 Jondalstunnelen	B. Ullensvang	* [yellow]	* [yellow]	* [yellow]	* [yellow]
		C. Kvinnherad	* [yellow]	* [yellow]	* [yellow]	* [yellow]
6	E39 Kvivsvegen	A. Volda	* [yellow]	* [yellow]	* [yellow]	* [yellow]
		B. Stryn	* [yellow]	* [yellow]	* [red]	* [yellow]
7	Fv609 Dalsfjordsambandet	A. Askvoll	* [yellow]	[yellow]	* [green]	* [yellow]
8	Fv616 Bremangersambandet 2	B. Bremanger	[yellow]	[red]	[yellow]	[yellow]
9	E39 Klett-Bårdshaug	A. Melhus	* [yellow]	* [yellow]	* [green]	* [yellow]
		B. Orkdal	* [yellow]	* [green]	* [green]	* [green]
		C. Skaun	* [green]	* [yellow]	* [yellow]	* [yellow]
10	Rv7 Sokna–Ørgenvika	A. Flå	[yellow]	[yellow]	[yellow]	[yellow]
		B. Krødsherad	[yellow]	[yellow]	[red]	[yellow]
		C. Ringerike	[yellow]	[yellow]	[yellow]	[yellow]

Notes:
* indicates if the impact was a stated objective of the project
Green – the analyses show a significant <u>increase</u>
Yellow – the analyses show <u>no change</u>
Red – the analyses show a significant <u>decrease</u>

Notes.
* indicates if the impact was a stated objective of the project.
Green – the analyses show a significant increase.
Yellow – the analyses show no change.
Red – the analyses show a significant decrease.

Projects that connect sparsely populated areas do not have positive impacts on settlement.

Economic development is often one of the main strategic objectives for road projects, but we find an increase in the number of new firms for just three of the projects. In two of the projects, we find a decrease. It is challenging to identify clear relationships, but we note that several of the positive impacts are in municipalities near the largest cities.

Employment in existing companies show a similar trend, with an increase in the numbers of employees for three projects. In the other projects, the new roads have not led to any changes in employment.

Given the mixed results presented here, it is not surprising that few studies find clear evidence of the impact of transport infrastructure improvements on local development. We find several examples of negative impacts, and hence possible evidence for the two-way road effect. Although the impacts in many areas are positive, there is no evidence to suggest that road investment is a generally potent instrument. Positive local impacts appear to occur only in cases where relatively weak areas have experienced significantly improved connections to larger labour markets.

Most of the roads in our sample are in areas with few existing roads and alternative routes. They resulted in large travel time savings and considerable improvements in accessibility. Despite this, the impacts were smaller than one might have expected.

The projects with no tolls (no. 6, 7 and 8) shows little sign of having larger local impacts. For these projects, the tendency is fewer cases with any impact than for the other projects. Other differences between the projects are therefore probably more important than only the difference in tolls. For two of the case (no. 1 and 9) we have observations of at least five years after the removal of toll. Despite this reduction in travel cost, there is no clear sign of any additional impact on our indicators. Note that we do not claim the tolls are irrelevant, but rather that the benefit from the travel time reduction seems be more important.

5. Concluding comments

In this paper, we have studied the wider local impacts of new and improved roads. Traditionally, cost-benefit analyses (CBAs) have been used to evaluate the merit of projects ex ante and ex post, but there is increasing recognition that single point metrics, such as the benefit-cost ratio, may favour projects in areas that already enjoy stable economic growth. Therefore, many projects that are estimated to provide value for money may be poorly aligned with objectives relating to strategic policy.

Studies of practical decision-making have shown that politicians and other stakeholders emphasise other aspects than those that are covered by the CBA. This has led to a search for benefits that may boost value for money through agglomeration, increased competition, or labour market impacts. We have argued that wider economic impacts are uncertain and that even if there are positive net results for the economy as a whole, the impacts may be negative for left-behind areas that an intervention was initially designed to favour. In most countries, appraisal guidance emphasises the importance of including unintended and negative impacts in analyses, but most of the methodological development has been based on a search for additional benefits rather than identifying impacts on different groups and regions.

Instead, we have estimated the wider local impacts arising in secondary markets on communing, population, new firms, and employment

– indicators that can measure the achievement of objectives for local growth, which often is the intention of government intervention. As new roads can make a significant difference to local distribution of economic activity, we have studied the impacts over a larger influence area, covering a total of 20 municipalities. However, there may be larger areas of influence that we have not identified.

Our results show that some municipalities experience positive development impacts when roads are improved, but for some the impacts are negative. These results may be in line with the findings of Banister and Berechman (2001), who argued that improved transport infrastructure is more likely to reinforce existing trends rather than break them. If the conditions for investments and growth already are favourable, better roads can increase the attractiveness of one area over another, and exacerbate rather than mitigate spatial disparities (Overman, 2020). In our opinion, this is an indication that the two-way effect is real and may at worst lead to deprived areas becoming even worse off. Intention is not the same as outcome (Goodwin, 2010), and planners and promoters should be aware that transport interventions could have negative distributional impacts. Therefore, knowledge of past scheme's performance, as presented in this paper, should be useful for future appraisals.

Author statement

The contributions to this paper were as follows.

Morten Welde: Project administration; conceptualization; literature review; analysis of data; discussion; conclusion; writing – review and editing. Eivind Tveter: Conceptualization; literature review; data collection; methodology; analysis of data; discussion; conclusion; writing – review and editing.

Appendix A. Results using in-County donor pools

Fig. A1. Employment gap between treated municipality and the synthetic control by project. Opening year = 0. County specific donor pool.

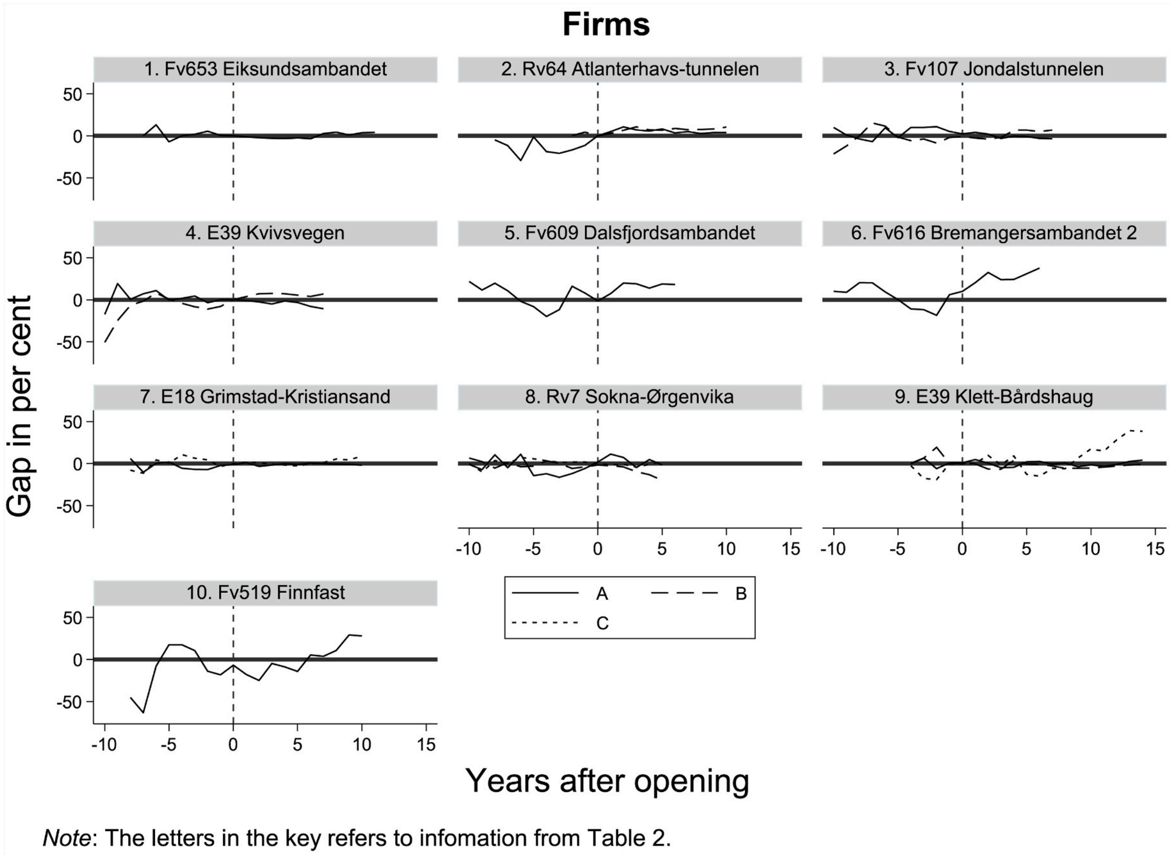

Fig. A2. Firms gap between treated municipality and the synthetic control by project. Opening year = 0. County specific donor pool.

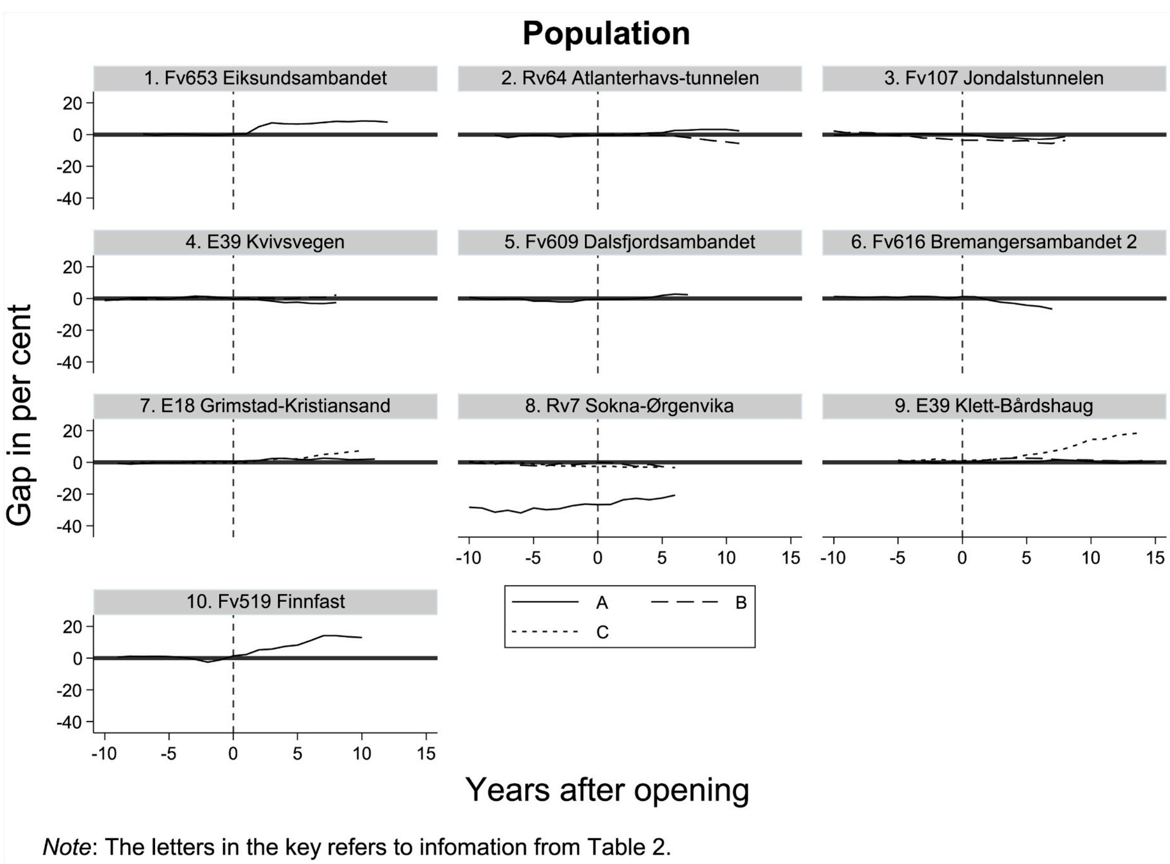

Fig. A3. Population gap between treated municipality and the synthetic control by project. Opening year = 0. County specific donor pool.

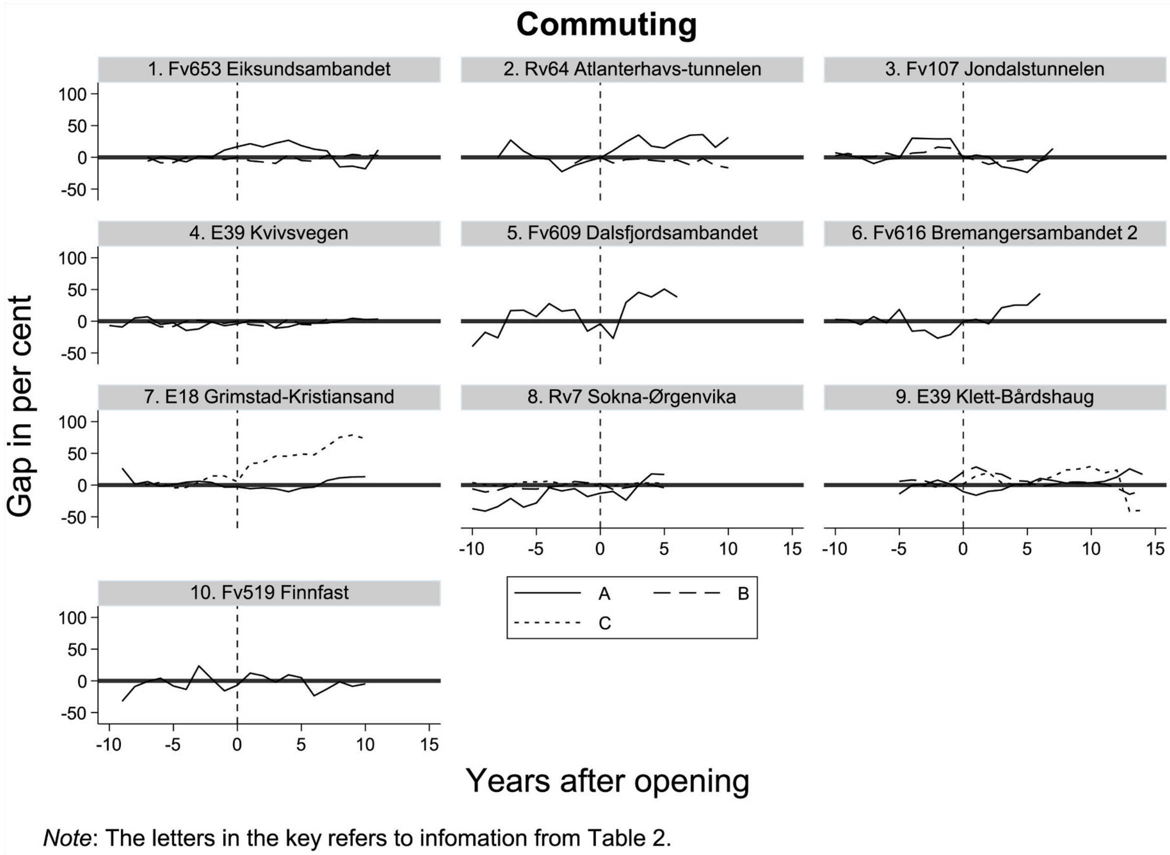

Fig. A4. Commuting gap between treated municipality and the synthetic control by project. Opening year = 0. County specific donor pool.

Appendix B. Construction of the synthetic control units

Table B1
Number of units in the donor pool

Project		Trimmed donor pool				In-county			
	Municipality	Commuting	Employment	Firms	Population	Commuting	Employment	Firms	Population
1	Ulstein	24	51	48	57	25	25	24	24
2	Averøy	67	56	62	66	25	25	24	24
	Kristiansund	28	18	30	37	25	25	24	24
3	Kvinnherad	60	44	40	49	37	37	38	38
	Ullensvang	39	46	54	48	37	37	38	38
4	Stryn	47	51	55	57	37	37	38	38
	Volda	28	49	55	46	25	25	24	24
5	Askvoll	37	74	60	74	37	37	38	38
6	Bremanger	53	70	50	67	37	37	38	38
7	Grimstad	18	28	29	41	24	24	24	24
	Kristiansand	9	3	5	5	24	24	24	24
	Lillesand	29	53	46	49	24	24	24	24
8	Flå	32	32	48	32	50	50	50	50
	Krødsherad	63	67	61	64	50	50	50	50
	Ringerike	16	16	25	29	50	50	50	50
9	Melhus	27	51	38	41	38	38	37	38
	Orkdal	27	44	48	44	38	38	23	38
	Skaun	69	71	62	59	38	38	37	38
10	Finnøy	55	70	47	76	23	23	23	23
	Mean	**38**	**47**	**45**	**50**	**34**	**34**	**33**	**34**
	Min.	**9**	**3**	**5**	**5**	**23**	**23**	**23**	**23**
	Max	**69**	**74**	**62**	**76**	**50**	**50**	**50**	**50**

Table B2
Construction of the synthetic control units. Indicator: Firms

Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight
7A: Askvoll		**2A: Averøy**		**8A: Bremanger**		**3A: Grimstad**	
Suldal	0.47	Andøy	0.39	Grane	0.10	Kongsberg	0.21
Sande	0.18	Fjaler	0.09	Sørfold	0.03	Øvre Eiker	0.19
Fjord	0.12	Vaksdal	0.08	Ulvik	0.03	Vågan	0.16
Tingvoll	0.05	Tingvoll	0.03	Other	0.84	Sola	0.06
Other	0.19	Other	0.41			Other	0.39
10A: Flå		**4A: Finnøy**		**3B: Kristiansand**		**2B: Kristiansund**	
Nesna	0.38	Kvæfjord	0.71	Drammen	0.64	Holmestrand	0.07
Grane	0.30	Sørfold	0.23	Ålesund	0.36	Sola	0.05
Snåase - Snåsa	0.17	Etnedal	0.06			Aurskog-Høland	0.04
Karlsøy	0.15					Other	0.84
10B: Krødsherad		**5A: Kvinnherad**		**3C: Lillesand**		**Melhus**	
Fjord	0.18	Notodden	0.47	Gran	0.57	Levanger	0.40
Tingvoll	0.09	Østre Toten	0.20	Levanger	0.14	Gran	0.28
Hemnes	0.03	Aurskog-Høland	0.19	Eigersund	0.07	Vågan	0.09
Other	0.70	Nesodden	0.14	Hadsel	0.02	Austevoll	0.09
						Other	0.14
Orkdal		**10C: Ringerike**		**9C: Skaun**		**6A: Stryn**	
Vestvågøy	0.21	Øvre Eiker	0.68	Sande	0.25	Flekkefjord	0.23
Klepp	0.12	Indre Østfold	0.17	Meråker	0.19	Nome	0.22
Hadsel	0.05	Øygarden	0.13	Lyngen	0.07	Løten	0.16
Gran	0.03	Other	0.01	Vinje	0.05	Tysvær	0.11
Other	0.60			Other	0.43	Other	0.29
5B: Ullensvang		**1B: Ulstein**		**1B/6B Volda**			
Østre Toten	0.19	Nord-Aurdal	0.19	Austevoll	0.22		
Nord-Aurdal	0.12	Østre Toten	0.14	Brønnøy	0.07		
Porsanger	0.09	Hadsel	0.06	Søndre Land	0.06		
Vestnes	0.06	Rælingen	0.04	Other	0.35		
Other	0.54	Other	0.56				

Table B3
Construction of the synthetic control units. Indicator: Commuting

Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight
7A: Askvoll		**2A: Averøy**		**8A: Bremanger**		**3A: Grimstad**	
Fyresdal	0.60	Fitjar	0.41	Rendalen	0.37	Alver	0.60
Grane	0.23	Sømna	0.26	Tysnes	0.29	Karmøy	0.21
Rødøy	0.17	Evje og Hornnes	0.18	Etnedal	0.25	Bjørnafjorden	0.20
				Other	0.09		
10A: Flå		**4A: Finnøy**		**3B: Kristiansand**		**2B: Kristiansund**	
Rødøy	0.50	Nesna	0.24	Haugesund	0.98	Øvre Eiker	0.24
Karlsøy	0.27	Bykle	0.08	Other	0.02	Midt-Telemark	0.03
Vardø	0.10	Vanylven	0.08			Gjesdal	0.03
Beiarn	0.09	Other	0.69			Sortland - Suortá	0.03
Other	0.05					Other	0.66
10B: Krødsherad		**5A: Kvinnherad**		**3C: Lillesand**		**Melhus**	
Fitjar	0.18	Fitjar	0.25	Vefsn	0.60	Bjørnafjorden	0.50
Kvitsøy	0.09	Sande	0.02	Nord-Aurdal	0.22	Hå	0.42
Rauma	0.07	Other	0.73	Gjesdal	0.19	Other	0.08
Deatnu - Tana	0.04						
Nesna	0.04						
Other	0.58						
Orkdal		**10C: Ringerike**		**9C: Skaun**		**6A: Stryn**	
Gjesdal	0.26	Sogndal	0.43	Fitjar	0.19	Gulen	0.37
Eigersund	0.09	Bamble	0.34	Flesberg	0.15	Tjeldsund	0.35
Notodden	0.07	Sunnfjord	0.19	Øystre Slidre	0.06	Jevnaker	0.23
Alta	0.03	Tysvær	0.03	Gulen	0.05	Risør	0.05
Kinn	0.03			Other	0.55		
Other	0.53						

(*continued on next page*)

Table B3 (*continued*)

Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight
5B: Ullensvang		**1B: Ulstein**		**1B/6B Volda**			
Holmestrand	0.15	Gjesdal	0.80	Østre Toten	0.28		
Alta	0.09	Hustadvika	0.20	Bjørnafjorden	0.25		
Sel	0.09			Hå	0.23		
Hadsel	0.09			Gjesdal	0.09		
Nordre Land	0.06			Sel	0.03		
Other	0.52			Other	0.13		

Table B4
Construction of the synthetic control units. Indicator: Population

Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight
7A: Askvoll		**2A: Averøy**		**8A: Bremanger**		**3A: Grimstad**	
Lødingen	0.45	Sigdal	0.22	Bremanger	1.00	Nittedal	0.19
Gulen	0.05	Saltdal	0.02	Øksnes	0.28	Østre Toten	0.07
Kvæfjord	0.05	Other	0.76	Deatnu-Tana	0.09	Strand	0.03
Nordkapp	0.05			Sauda	0.04	Other	0.71
Other	0.40			Other	0.78		
10A: Flå		**3B: Kristiansand**		**2B: Kristiansund**		**10B: Krødsherad**	
Bykle	0.38	Sarpsborg	0.28	Holmestrand	0.09	Hjelmeland	0.35
Lebesby	0.37	Nordre Follo	0.12	Eigersund	0.05	Lebesby	0.06
Fyresdal	0.11	Fredrikstad	0.05	Gjøvik	0.03	Hurdal	0.03
Other	0.14	Bærum	0.03	Rælingen	0.03	Other	0.55
		Other	0.52	Other	0.81		
5A: Kvinnherad		**3C: Lillesand**		**Melhus**		**Orkdal**	
Hammerfest	0.48	Råde	0.18	Klepp	0.25	Klepp	0.10
Østre Toten	0.04	Nannestad	0.08	Malvik	0.22	Verdal	0.06
Midt-Telemark	0.04	Other	0.74	Eidsvoll	0.07	Ås	0.03
Hustadvika	0.03			Nittedal	0.03	Other	0.81
Other	0.41			Other	0.42		
10C: Ringerike		**9C: Skaun**		**6A: Stryn**		**5B: Ullensvang**	
Sunnfjord	0.40	Andøy	0.25	Kvam	0.41	Målselv	0.66
Holmestrand	0.37	Overhalla	0.17	Indre Fosen	0.28	Midt-Telemark	0.34
Molde	0.08	Sauda	0.16	Brønnøy	0.17		
Gjøvik	0.07	Enebakk	0.12	Grue	0.14		
Other	0.08	Other	0.32				
1B: Ulstein		**1B/6 BVolda**					
Gjerdrum	0.19	Målselv	0.08				
Råde	0.06	Gausdal	0.04				
Rakkestad	0.03	Notodden	0.02				
Enebakk	0.02	Malvik	0.02				
Other	0.70	Other	0.84				

Table B5
Construction of the synthetic control units. Indicator: Employment

Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight
7A: Askvoll		**2A: Averøy**		**8A: Bremanger**		**3A: Grimstad**	
Hjelmeland	0.40	Nome	0.10	Kautokeino	0.58	Smøla	0.10
Sokndal	0.16	Herøy	0.08	Hjelmeland	0.20	Tokke	0.09
Rendalen	0.16	Søndre Land	0.05	Fitjar	0.18	Fjaler	0.08
Sande	0.03	Stranda	0.05	Gulen	0.04	Sirdal	0.08
Other	0.25	Luster	0.04			Drangedal	0.03
		Other	0.68			Other	0.63
10A: Flå		**3B: Kristiansand**		**2B: Kristiansund**		**10B: Krødsherad**	
Fyresdal	0.60	Drammen	0.48	Lillehammer	0.15	Vanylven	0.51
Etnedal	0.20	Stavanger	0.42	Kongsvinger	0.06	Åseral	0.35
Vega	0.15			Halden	0.06	Våler (Viken)	0.08
Loppa	0.05			Kongsberg	0.06	Bykle	0.06
				Time	0.04		

(*continued on next page*)

Table B5 (*continued*)

Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight	Synthetic control	Weight
				Other	0.62		
5A: Kvinnherad		**3C: Lillesand**		**Melhus**		**Orkdal**	
Østre Toten	0.35	Gjesdal	0.32	Risør	0.35	Vestby	0.18
Sogndal	0.25	Kvinesdal	0.05	Øvre Eiker	0.18	Gjesdal	0.16
Øvre Eiker	0.08	Råde	0.04	Rælingen	0.12	Eigersund	0.16
Vestby	0.04	Other	0.29	Gloppen	0.04	Aurkog-Høland	0.05
Other	0.28			Other	0.31	Other	0.45
10C: Ringerike		**9C: Skaun**		**6A: Stryn**		**5B: Ullensvang**	
Horten	0.43	Marker	0.09	Risør	0.39	Østre Toten	0.60
Lier	0.29	Våler (Viken)	0.08	Vennesla	0.13	Tinn	0.17
Lillehammer	0.18	Sande	0.06	Holmestrand	0.05	Eidsvoll	0.06
Arendal	0.11	Hamarøy - Hábmer	0.04	Other	0.43	Notodden	0.06
		Other	0.74			Other	14
1B: Ulstein		**1B/6B Volda**					
Gjesdal	0.73	Lyngdal	0.22				
Other	0.17	Eigersund	0.07				
		Austevoll	0.07				
		Modum	0.05				
		Alstahaug	0.04				
		Other	0.55				

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