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Estimating the Labour Market Impacts of Transport Projects in Finland

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Abstract

Effects on labour market outcomes are often referred to when discussing the wider economic benefits of transport projects. However, research on the topic in the Finnish context is scarce. Thus, proponents of transport projects may put exaggerated hopes on the labour market effects when arguing for the projects. This review aims to give researchers a good starting point for analyzing the labour market effects of transport projects in Finland. We review theoretical frameworks and recent empirical literature on the effects of transport projects and accessibility on the labour market. We discuss the available data sources in Finland and methodological considerations for analyzing causal effects. Furthermore, we explore the integration of labour market impacts into cost-benefit analyses considering, for example, the risk of double-counting benefits.

Tiivistelmä

Liikennehankkeiden työmarkkinavaikutusten arviointi Suomessa

Liikennehankkeiden laajemmista taloudellisista vaikutuksista puhuttaessa mainitaan usein niiden vaikutukset työmarkkinatulemiin. Suomalaista tutkimusta aiheesta ei ole kuitenkaan juurikaan tehty. Tutkimuksen puutteen seurauksena liikennehankkeita perusteltaessa saatetaan niiden työmarkkinavaikutuksille laittaa liikaa painoarvoa. Katsauksessamme pyrimme luomaan hyvät lähtökohdat liikennehankkeiden työmarkkinavaikutusten empiiriselle tutkimiselle Suomessa. Käymme lyhyesti läpi teoreettisia viitekehyksiä ja viimeaikaista empiiristä tutkimusta liikennehankkeiden ja saavutettavuuden vaikutuksesta työmarkkinoihin. Esittelemme empiirisiä lähestymistapoja, joita on käytetty kausaalisten vaikutusten tutkimiseen, ja tutkimukseen käytettävissä olevia datalähteitä Suomessa. Lopuksi käymme läpi, miten työmarkkinavaikutukset voidaan sisällyttää liikennehankkeiden hyöty-kustannusanalyysiin ilman hyötyjen kaksinkertaisen laskennan vaaraa.

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Keywords: Transport project, Labour market, Wider economic impacts, Empirical research

Asiasanat: Liikennehankkeet, Työmarkkinat, Laajemmat taloudelliset vaikutukset, Empiirinen tutkimus

JEL: R42, H43, J68, H54

1 Introduction

The effects on labour market outcomes including agglomeration benefits are often referred to when discussing the wider economic benefits of transport projects[1]. Thus, demand for well conducted, peer-reviewed work on the wider economic benefits is growing. However, the availability of such research on Finnish projects remains limited, with only a few exceptions such as the property market analysis of the Raide-Jokeri project published in the Journal of the Finnish Economic Association (Kauria, 2021). At the same time, some large transport projects have been promoted with possibly misleading and inflated claims on their effects on the labour markets.[2] There is a particular demand for well-executed research, especially concerning large-scale railway projects and urban transit developments.

In this paper, we review the effects of transport projects on labour market outcomes based on theoretical frameworks and recent empirical literature. We present the available data sources in Finland and discuss considerations for analysing causal effects when studying the impacts of transport projects and accessibility on labour market outcomes. Finally, we present the Finnish cost-benefit analysis framework and explore how these benefits and impacts should be accounted for in cost-benefit analyses considering the risk of double counting some of the benefits. Although some of the empirical evidence presented

[1] Throughout this paper, we use the term transport project to describe all kinds of interventions and policies that alter the transport network. In places where appropriate, we specify the type of the project being discussed, such as transport infrastructure project.

[2] See, for example, "HSL's report: The Pisara Rail would bring tens of thousands of work years" *HSL:n selvitys: Pisararata toisi kymmeniä tuhansia työvuosia maakuntiin* (`https://yle.fi/a/3-7979543`)

comes from structural models, this paper concentrates on how to estimate reduced form estimates of labour market outcomes of transport projects. For a review of structural modelling of the interaction between transport projects and labour markets, see for example Redding and Rossi-Hansberg (2017).

The paper proceeds as follows. We begin by presenting a brief literature review. In section 2. we present the theoretical frameworks and empirical findings regarding the impacts of transport projects on labour market outcomes, and how the results generalize to other contexts. In Section 3, we discuss data requirements for empirical work and how the effects could be studied, including the common pitfalls one may encounter. We also present available data sets and resources in Finland. In Section 4, we review cost-benefit analysis of transport projects and how labour market impacts should be incorporated to cost-benefit analyses without double counting some of the benefits. Finally, we conclude by discussing some future avenues for transport research in Finland.

2 Brief literature review

2.1 Theoretical literature

There are three possible channels through which transport projects may affect the labour market: 1) the supply of labour, 2) the demand for labour, and 3) matching (see, for example, Gibbons and Machin (2006) for an excellent review).[3] Figure 1 illustrates how different channels also interact with each other. For example, if labour supply increases due to lower commuting costs,

[3]This section is partly based on Metsäranta et al. (2019).

the reservation wage decreases, reducing the wage level, which in turn may negatively affect labour supply. Thus, the overall impact on labour supply remains unclear and is mainly an empirical question. Hence, based on theory, we cannot determine whether the income or substitution effect of wage changes is greater.

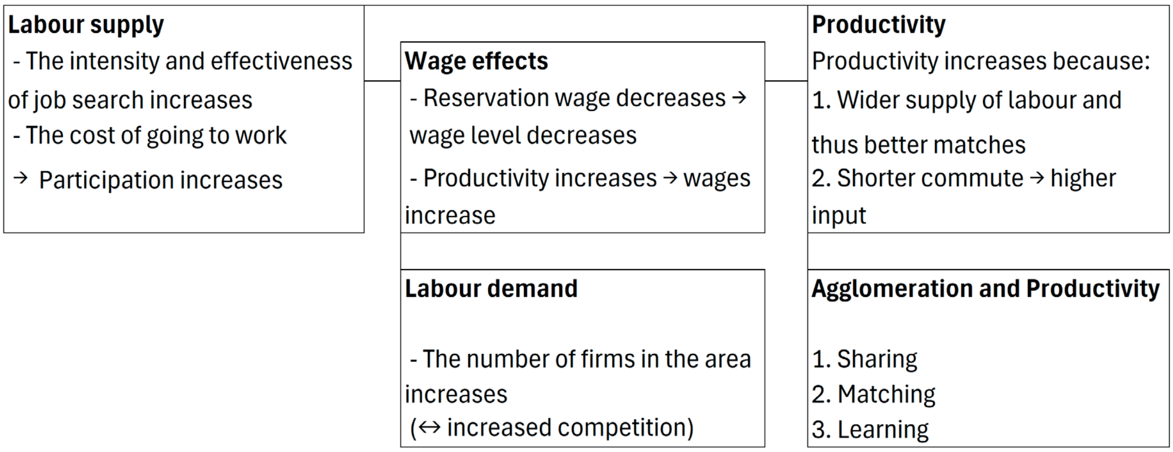

Figure 1: The effects of lower transport costs or better accessibility on the labour market. Adapted from Metsäranta et al. (2019).

Moreover, agglomeration effects and the effects of other channels may overlap to some extent. Transport projects not only increase agglomeration through decreased travel times, but can also influence the location of establishments, thus leading to economic agglomeration. Regarding the impact of transport projects on the location of businesses, theoretical literature has identified two opposing channels. On the one hand, improved transport connections attract businesses through cost savings, but on the other hand, there is increased competition, which may, in turn, reduce attractiveness. Several papers have modelled the positive relationship between economic agglomeration and productivity. Many of these studies conclude that better transport connections lead to denser economic activity, which, in turn, leads to higher productivity. Fujita and Thisse (2002) discuss economic agglomeration and the theories explaining it. Duranton and Puga (2004) provide a summary of the fundamentals of urbanization and the literature focusing on these fundamentals. They identify three main channels through which economic agglomeration occurs: sharing, matching, and learning. Sharing is based on the idea that there are indivisible activities and spaces, such as factories, where a broader sharing of associated fixed costs increases returns. Increased economic agglomeration also enables sharing of a wider range of intermediate goods, expertise and risks, which in turn increases total returns. Matching, as identified in the literature, has two manifestations. Broader labour markets and greater availability of labour improve the probability and quality of matching between workers and jobs, and economic agglomeration can reduce delays in contract finalization because there is a larger pool of potential contracting partners. The third channel of agglomeration benefits is learning: Economic clusters, such as cities, provide favourable conditions for knowledge creation, transmission, and accumulation.

There are also many complexities to consider. For example, labour markets might be relatively local (in the sense that the attractiveness of jobs declines steeply with distance), and local interventions (such as improved transport links) might have only modest effects on a larger area (Manning and Petrongolo, 2017). Moreover, there may be adverse labour market effects after transport improvements if the following commuting cost reductions make it easier to commute to low productivity areas (see, for example, Eliasson and Fosgerau, 2019). In the next section, we review empirical literature on the labour market impacts of transport projects.

2.2 Empirical evidence

Before presenting recent empirical work on the labour market impacts of transport projects, some remarks should be noted.[4] First, most of the literature reviewed here is based on quasi-experimental evidence of realized transport projects. Second, many studies primarily focus on regional impacts and do not assess the overall economic effect of the projects. The potential outcomes observed, such as increased employment, might not be due to changes in the transport system but due to, for example, relocation of labour; employed individuals tend to live in and relocate to places with good transport connections. Hence, the transport project itself may not increase employment but merely induce relocation of employed individuals from one location (potential control group) to another (the treatment group). Even if one excludes the negatively affected area from the analysis, the bias of overvaluation of the benefits of the project still exists. Third, most of the existing empirical literature focuses mainly on what happens to labour supply, demand, and productivity. The research does not address whether the resources invested in the project could have produced greater returns elsewhere or whether it generates more benefits than what it has cost. In section 3, we will present the Rubin causal model, through which these challenges can be better understood.

[4] This section is partly based on Metsäranta et al. (2019).

Public transport We begin the examination of the impact of transport projects with studies concerning public transit initiatives. Åslund et al. (2017) investigate the impact of the introduction of the local train connection, Upptåget, on labour market outcomes in Sweden. Prior to the local train, bus connections operated between the municipalities of Heby, Tierp, Uppsala, and Östhammar, in addition to long-distance trains between Stockholm, Uppsala, and Tierp. During the 1990s, the number of local train connections and travel speed between Tierp and Uppsala increased. The price of travel remained the same, so the only change was in travel time.[5] The authors do not find any impact of shortened commuting time on wages or the likelihood of being employed, even though the number of local train connections and travel speed increased significantly.

Heres et al. (2014) study the introduction of the TransMilenio Bus Rapid Transit (BRT) in Bogotá, Colombia and find a positive impact on wages in areas near BRT stations. However, the results suggest that the newly built stations increased selective migration to those areas rather than directly affecting the wage levels of residents who originally lived there. The new stations also did not affect the employment rates in the areas that received BRT stations.

Tyndall (2021) study the effect of light rail transit on local employment in four US cities with reduced form and structural modelling techniques. These four cities received new light rail lines, and the new light rail stops are used as an accessibility shock to those areas. Airport corridors are used as an instru-

[5]One of the goals of the train connection was to reduce bus congestion in Uppsala and expand job markets for those living in the north.

ment to combat endogenous placement of the stops.[6] In reduced form examinations, Tyndall (2021) finds that areas that receive light rail stops increase their employment. However, according to his structural neighbourhood choice model, the labour market effects are mostly due to endogenous neighbourhood sorting. He assesses the effect of light rail systems on employment with the structural model and finds that the light rail systems decreased employment in each city. He attributes the result to the fact that light rail stations increased amenities near them and thus increased housing prices. This pushed lower income residents to lower accessibility areas, which decreased the residents' probability of employment. Meanwhile the employment probability of the high-income residents who moved near the light rail stations stayed mostly the same.

Pogonyi et al. (2021) examine the effect of a new metro line in London on the displacement of establishments from nearby areas closer to the metro stations. They use a newly built metro line to assess how the number of establishments and the number of employed was affected by these newly built stations. They use several instrumental variable techniques to combat different sources of endogeneity. Their results suggest that the newly built metro stations only moved establishments closer to the stations but did not cause any increase in the number of establishments regionally.

Road projects Chandra and Thompson (2000) study the impact of interstate highways on economic growth in the United States from 1969 to 1994.

[6] An airport corridor is defined as a straight line corridor from the city centre to the main airport of the city.

They focus on non-metropolitan counties to reduce the endogeneity related to the placement of the highways. They find that new highways stimulate economic activity in counties they pass through but do so at the expense of adjacent counties, resulting in a net economic impact of zero.

Holl (2004) obtains similar results; she examines the impact of road networks on the location of new production facilities in Spain from 1980 to 1994, when most of the country's highway network was built. She uses variation in municipalities' distance to the nearest highway that results from new highways being constructed. She finds that the proximity of road infrastructure significantly influences the location of new production facilities, but this impact occurs partly at the expense of more distant locations.

Gibbons et al. (2019) examine the impact of changes in minimum travel times caused by new road projects on firms' operations in England. They find that road projects increase the number of firms and employment in areas that improved their accessibility due to the projects. Employment growth occurred through new firms, while it did not happen in existing firms.[7] Fretz et al. (2022) use the construction of the Swiss highway network along with a spatial equilibrium model to study accessibility's effect on income sorting across Switzerland. They find that the introduction of new highway access resulted in a sustained 24% rise in the proportion of high-income taxpayers over

[7] Sanchis-Guarner (2012) uses a similar empirical setting as Gibbons et al. (2019). Her discussion paper is the first to provide causal evidence on how changes in accessibility due to road projects can affect workers' labour market outcomes. When examining the impact of accessibility changes on a specific residential-work area combination, she finds a positive effect on hours worked and wages, which may be explained by increased competition and wage growth due to agglomeration. Some workers transition from part-time to full-time employment. However, she finds that accessibility changes in the worker's residential area have no effect on wages or hours worked.

the long term, alongside an 8% decline in the share of low-income taxpayers, impacting segregation by income in Switzerland. Additionally, new highways contributed to both job and residential urban sprawl.

Other transport projects Bütikofer et al. (2022) examine the impact of access to larger labour markets on wages and employment by exploiting the opening of the Öresund bridge between Denmark and Sweden.[8] They show that the bridge generated a substantial increase in the cross-country commuting behaviour of Swedes driven both by extensive and intensive employment responses and a 13.5% increase in the average wage of workers in the region. However, the wage gains are unevenly distributed: the effect is largest for high-educated men and smallest for low-educated women. Thus, the wage gains come at the cost of increased income inequality and a widening of the gender wage gap.

Finally, Amior and Manning (2019) examine the regional disparities in employment rates and how migration and commuting traffic do not fully mitigate disruptions in labour demand. Using neighbourhood-level employment and commuting data from the UK, they estimate a structural model and demonstrate how the probability of commuting sharply declines with distance and how labour markets are highly localized (as also shown in Manning and Petrongolo, 2017). They also show how lower commuting costs (for example, due to

[8] It takes approximately 10 minutes to cross the bridge, and the average travel time from the centre of Malmö to the centre of Copenhagen is 27 minutes by train and 35 minutes by car. Before the bridge opened, the cost of commuting between Denmark and Sweden was high, especially when accounting for the time it took to cross the strait. The Helsingborg-Helsingör ferry line was the predominant mode of transport, and it took approximately 1 hour and 45 minutes to go from Malmö to Copenhagen via this ferry line.

infrastructure improvements) reduce regional disparities in local employment rates, but only to a small extent.

Agglomeration elasticities There is a vast literature studying agglomeration elasticities. Most of these studies measure productivity using wages or total factor productivity (Combes and Gobillon, 2015). The underlying assumption in the studies using wages is that in a market equilibrium, wages reflect productivity. Proost and Thisse (2019) find in their review that when differences in skills and other factors affecting worker productivity are taken into account, the elasticity of worker productivity with respect to density is slightly below 0.03, meaning that when density doubles, productivity increases by about 2.1 percent. Similarly, Donovan et al. (2024) find in their meta-analysis that the agglomeration elasticity of productivity is 0.026 (with a 95% confidence interval of 0.015 to 0.039).[9]

A recent policy report studying the effects of agglomeration on wages and value-added per worker in Finland (Haapamäki et al., 2024) uses a similar setting and strategy as in Knudsen et al. (2022) and Börjesson et al. (2019). Haapamäki et al. (2024) find an elasticity of 0.045 on wages. However, the findings concerning the value-added at establishment level are less conclusive and statistically insignificant. The results also suggest that increased accessibility leads to increases in other operating expenses such as rents, potentially

[9]Donovan et al. (2024) use 6,684 agglomeration elasticity estimates from 294 studies conducted in 54 countries over six decades. About three-quarters of these studies have been published after the paper by Combes et al. (2008), which demonstrates the importance of selection bias on the obtained elasticity estimates, and the dataset used significantly differs from that used, for example, in the meta-analysis by Melo et al. (2009). They are also able to account for publication bias. Like previous meta-analyses (for example, Melo et al., 2009), they identify that studies using more precise data tend to find smaller elasticity estimates.

explaining the lack of statistically significant effect on value-added.

2.3 Generalizability of the results

Several empirical and theoretical studies highlight how difficult it is to generalize the labour market impacts of a specific transport project to other projects.[10] The literature has found varying effects depending on factors such as the functional form of structural models or empirical perspectives.

Welde and Tveter (2022) investigate the impact of ten transport projects on commuter traffic, population, employment, and the number of new businesses using synthetic control groups in Norway. Significant time savings (5–60 minutes) in travel time were calculated for all projects except for one. Apart from one transport project, none of the projects had a positive impact on all four aforementioned factors; some had negative effects, while others had positive ones. Overall, the projects did not have a significant impact on the listed factors, even though these factors were included in the projects' objectives.

According to Oosterhaven and Knaap (2017), the relationship between production and infrastructure found in historical macro data cannot be directly applied to the evaluation of new projects; instead, several factors such as the characteristics of the transport project and its location must be considered. Venables et al. (2014) also emphasize the importance of conducting project-specific assessments. According to Deng's (2013) review, three main factors underlie differences in impacts that should be considered in project evaluation: 1) country-specific characteristics (such as the ability to efficiently utilize new

[10] This subsection is partly based on Metsäranta et al. (2019).

transport projects), 2) the type and quality of the transport project, and 3) the condition of the existing transport network.

Moreover, relative location may have an impact on labour market outcomes (see, for example, Koster et al., 2022). Koster et al. (2022) utilizes planned and implemented railway projects mainly in Japan to examine winning and losing regions. They demonstrate, based on both theoretical models and empirical research, how a railway connection may not necessarily boost employment in remote or mid-range areas and could even decrease it. Their findings highlight the importance of relative location within the railway and road network and help explain why some regions are losers while others are winners.

3 Empirical strategies and data requirements

In this section, we present some common challenges in inferring causal relationships between transport projects and labour market effects, and strategies used to address them. Some of the challenges can be circumvented with high quality spatial data, but overcoming others may require knowledge about the specifics of the project, plans, context, or other creative solutions. We also present Finnish data sources that can be used in studying the labour market effects of transport projects.

3.1 Empirical setting

Studying how transport projects affect employment and productivity requires a well-designed research framework, allowing for the comparison of individuals affected by the project with similar individuals that are unaffected by the project.[11] We demonstrate the perfect setting and deviations from it through the Rubin causal model, that will structure our presentation of empirical challenges. The Rubin causal model consists of the potential outcomes framework and an assignment mechanism (Rubin, 2005). For ease of exposition, we consider the case of inferring causal outcomes for a binary treatment $D \in 0, 1$. The potential outcomes framework consists of units of observation i, covariates X_i, and the potential outcomes $Y_i(D = 1)$ and $Y_i(D = 0)$, where the outcome $Y_i(D = 1)$ refers to the outcome of unit i, when they are treated and the outcome $Y_i(D = 0)$ refers to the case when they are not treated. The causal effect β of the treatment for unit i is then defined from the two outcomes $Y_i(1)$ and $Y_i(0)$ usually as the difference $\beta = Y_i(1) - Y_i(0)$ but also other definitions such as the ratio $\beta = Y_i(1)/Y_i(0)$ are possible.

To be able to describe the causal effect of treatment, we require an assumption commonly referred to as the *Stable unit value treatment assumption* (SUTVA). This assumption states that the outcome of unit i does not affect the outcomes of the other units $j \neq i$ (Rosenbaum and Rubin, 1983) and that the way the intervention under research is made does not affect the outcomes $Y_i(1)$ and $Y_i(0)$.

The other part of the Rubin causal model is the assignment mechanism, which controls how the treatment is assigned to the units (Rubin, 2005). Imbens and Wooldridge (2009) classify these assignment mechanisms into three categories: i) random experiments, meaning mechanisms that assign the treat-

[11] This subsection is partly based on Metsäranta et al. (2019).

ment at random, ii) selection on observables, meaning mechanisms where the treatment probability does not depend on the potential outcomes, given the observable covariates of the units (the conditional independence assumption, Cox 1958), and iii) selection on unobservables, meaning all other mechanisms where the assignment probability may depend on the unobserved qualities of the units or potential outcomes of the treatment. The difficulty of analysing causal effects under each category of assignment mechanisms gets progressively more difficult. However, for the two first cases there are established and robust methods that can be used for uncovering the causal effects of treatment.

An optimal set-up for studying the effects of transport investments would involve randomizing areas that receive transport projects. This would ensure that the areas receiving transport projects and areas not receiving them would be similar in observable and unobservable qualities. Ideally, for SUTVA to hold the research setting should also ensure that migration, relocation of establishments or changes in traffic flows would not happen between the study areas or units. These kinds of conditions are of course impossibly restrictive, and in reality, researchers need to be mindful of potential violations of SUTVA and treatments that are assigned on observable or unobservable qualities of the units or outcomes. In the next section we review methods that are used in the literature to remedy the challenges posed by these realities.

3.2 Common pitfalls

Based on the framework presented in the previous section, we can split the main challenges regarding research settings in empirical research of transport investment into two possible sources: i) non-random assignment of the transport projects and ii) violations of SUTVA. The non-random assignment can further be classified into two categories: 1) self-selection of employed and more productive workers or establishments to areas with better accessibility and 2) reverse causality from endogenous placement of transport investment. Transport projects are undertaken where there is demand for them, for example due to growing population or employment. It is also possible that transport investment is targeted to economically declining regions to stimulate growth. In such cases, it can be difficult to distinguish the impact of the transport project from the region's general trends.

Additionally, violations of SUTVA happen when transport projects induce displacement of economic activity from further away areas to areas affected by the new infrastructure. This displacement might happen in local scale, or by shifting economic activity away from other regions. If these shifts are not observed and areas that suffer from the displacement are used as controls, the causal effects of the transport projects will be inflated. Thus, disentangling actual growth from displacement poses a significant challenge for the assessment of the totality and causality of labour market impacts of transport projects.

Further, we highlight a problem regarding data that affects spatial research in general, the modifiable areal unit problem (MAUP). This problem relates to the fact that spatial data is usually delivered in some kind of zonal divide, and data from different sources might not adhere to the same divide. The researcher then may have to aggregate data from different zonal divides, which can bring sizeable biases to estimations if done carelessly (Briant et al., 2010). Also, some phenomena might appear in such a small spatial scale, that studying them with large zones might not be feasible.

Next, we turn to the solutions that literature has used to remedy the aforementioned problems.

3.2.1 Selection on unobservables – endogenous placement and reverse causality

The literature has dealt with the endogenous placement of transport projects mainly by three different strategies: (1) planned route instrumental variables, (2) historical routes instrumental variables or (3) incidental place strategies. We introduce each of these strategies briefly. A more comprehensive review can be found in Redding and Turner (2015).

Planned routes instrumental variables. This strategy is based on the fact that transport plans go through many revisions and planners usually propose different routes from which the final transport route is chosen. These planned, but unrealised plans are used as an instrument to get rid of the endogeneity problems caused by endogenous placement. The relevance condition for instrument validity is typically satisfied, as the different planned routes are usually similar in nature. The instrument validity then rests upon the exogeneity of the unrealised plan. Arguments for the exogeneity of the unrealised plans to the outcome of interest are usually that the planners had different goals than labour market outcomes in mind for the unrealised routes. Baum-Snow (2007) explains that parts of the 1947 US interstate highway system were built with military use in mind and are thus exogenous for commuting, which is the outcome of interest. Pogonyi et al. (2021) argues that in London, unrealised metro station plans are a valid counterfactual for the realised Jubilee Line Extension metro.

Historical routes instrumental variables. This instrumental variable strategy resembles the one above, but the idea is to use old transport networks as instruments for current placement of transport routes. The argument for the exogeneity of historical routes on current labour market outcomes is that old enough transport networks (for example, Garcia-López et al. (2015) uses old Roman roads and Duranton and Turner (2012) US railroad network from the mid-1800s) are orthogonal for current transport needs. This orthogonality of past transport networks for current economic needs is argued to be due to structural changes in the economy. At least in developed countries, the economy has shifted from more agricultural and spatially spread economy to a more knowledge-intensive and spatially concentrated one. This structural change in economy also means that the needs for transport have changed, and historical transport networks do not have an impact on the modern economy except through their effect on current transport networks. The relevance for these historical routes instrumental variables stems from the fact that transport infrastructure is less costly to build to corridors that have or had some infrastructure before. Either the geographical conditions for building are favourable or the fact that groundwork for the infrastructure has already been done help reduce costs for new transport infrastructure. However, some evidence suggests that historical transport networks might have long persisting effects on economic outcomes possibly due to agglomeration economies or zoning (Brooks and Lutz, 2019), or due to acting as coordination devices for the placement of economic activity (Bleakley and Lin, 2012).

Incidental places strategy. In the third strategy the identification of causal effects stems from places that, despite not being the main focus of planners, incidentally, received better transport infrastructure by the virtue of being along the constructed route. The literature has identified two different ways of arguing for incidental changes for some areas. First, researchers might search for places that are either en route the actual areas the project is meant to connect. These kinds of places tend to be found, for example, along highways which are planned to facilitate movement between two cities or other major regions. Smaller villages or areas along the highway can then be thought to receive better transport infrastructure by chance (Chandra and Thompson, 2000). For public transport, some areas might get treated with a station by the virtue of some other reason than labour market effects. For example, Pogonyi et al. (2021) provide evidence that some areas in London received a metro station due to being on a least cost path between two economically motivated stations and Tyndall (2021) argues that some areas in American cities received light rail stations by virtue of being in the vicinity of airports. The other way to argue for incidental variation from transport projects is with the help of a continuous accessibility measure. With fine enough spatial data, the researcher can accurately measure changes in accessibility that can vary even over short distances. The accessibility improvement that a transport project causes to a certain place depends on the transport network that is already constructed around that place. These small differences in accessibility improvements due to previous transport infrastructure are incidental to the original plans for the placement of the transport project. Thus, this variation can be used to identify the effect of a transport project even when said project is endogenously placed. This line of argumentation has been used by, for example, Gibbons et al. (2019), Börjesson et al. (2019) and Haapamäki et al. (2024).

Other sources for exogenous variation. Other plausibly exogenous variation in transport networks have been used in the literature. These research settings make use of the differences-in-differences method and thus rely on the validity of the method's assumptions. The difference-in-differences method utilizes natural experimental situations with panel data, based on the main idea that the selection into the intervention is driven by some time-invariant unobservable factor, the effect of which on outcomes can be eliminated by comparing changes in outcomes between the experimental and control groups (see, for example, Pekkarinen, 2006). This enables the determination of the causal impact of the project, establishing a cause-and-effect relationship rather than mere correlation and producing valid estimates of the effects of individual interventions.

This method is, for example, used by Åslund et al. (2017), who use a difference-in-differences matching estimator to create observationally similar treatment and control groups. Although matching estimators are usually used to remedy selection bias, Åslund et al. (2017) specifically state that the use of matching estimator is to balance the observed qualities of treatment and control groups.

Using a different source of variation, Tyndall (2017) exploits a natural disaster that caused destruction of parts of the transport network as exogenous variation to identify transport infrastructure's effect on employment. He uses the flooding of a metro tunnel in New York that was caused by Hurricane Sandy in 2012 to estimate the effect of metro access to employment of people in the vicinity of the flooded metro line.

Nilsson (1991) found that *ex ante* analysed rate of return did not affect which transport projects were selected to the Swedish 10 year transport plan. Also Eliasson et al. (2015) found that the results from cost-benefit analyses did not affect the selection of transport projects in Norway and in Sweden even if civil servant's choices for transport projects were affected by the cost-benefit analysis (CBA) results, the choices that politicians made were only mildly affected. Börjesson et al. (2019) use these results as one piece of evidence to argue that the placement of transport infrastructure is actually exogenous for the economic phenomena examined, alleviating possible problems with assignment on unobservables. This line of thought of course depends on available research on the effect of CBA's or other *ex ante* metrics on choices of transport projects. Results from Norway and Sweden do not mean that the choices of politicians in other countries would not be influenced by *ex ante* economic evaluations of transport projects.

3.2.2 Violations of SUTVA – displacement effects

Violations of SUTVA are an important concern in many research questions regarding causal effects of transport projects. Changes in labour market outcomes due to transport projects may be area specific and come at the expense of areas that do not receive investment. This may reduce the total effect of transport investment and even make it negligibly small (Chandra and Thompson, 2000; Holl, 2004; Pogonyi et al., 2021). Studying the possible displacement to assess the total economic effects of transport investment requires data not only from the vicinity of the investment, but also from a larger area that might be negatively affected by the relocation of jobs and establishments. Redding and Turner (2015) suggest a reduced form approach with three kinds of areas to assess the displacement of economic activity. One of the areas is the one where the investment is located (i), another where activity might be shifted away from (ii) and a third that is not affected by the investment (iii). By comparing the areas (ii) and (iii) we find the amount of displaced economic activity, d. Then by comparing areas (i) and (ii), we can estimate the amount of shifted and added economic activity $2d + a$. By combining these estimates, we can then infer how much the transport project increased economic activity and how much of it was merely shifted from other regions. Naturally, this identification relies on some assumptions that might not be met in practice. Redding and Turner (2015) discuss those briefly.

3.2.3 Modifiable areal unit problem

Modifiable areal unit problem (MAUP) is a persistent challenge in all spatial research involving spatial units. Gehlke and Biehl (1934) were one of the first to note that the zonal divide that is used may affect the correlation coefficients and subsequently other metrics when calculated with different divides. The modifiable areal unit problem stems from two properties of dividing geography into smaller units: (i) the level of aggregation or the size of the zone and (ii) the way boundaries are drawn between the zones or the shape of the zone. The effect of these choices is illustrated in an example adapted from Briant et al. (2010). In Figure 2, imagine that black dots describe high-productivity workers and white dots describe low-productivity workers. First, each zone has the same density and number of high-productivity and low-productivity workers so that density and productivity does not seem to have an association. The size effect is illustrated by densifying the zonal divide, which leads into variation in the density of workers in each zone such that higher density zones have all the high-productivity workers and lower density zones are left with the low-productivity workers. The shape effect is illustrated by modifying the way the original four zones are drawn. This leads to once again lower density zones to have the low-productivity workers and high-density zones to have the high-productivity workers, although the relationship is not as clear, as the densities are closer together. By choosing different ways to divide the geography, the analysis can yield varying conclusions about, for example, the relationship between productivity and density.

Briant et al. (2010) study how the size and shape effects distort the analysis of spatial concentration, agglomeration economies and trade determinants. Results using simulated data show that with equally shaped spatial units, there is not much distortion of the data in either summing or averaging over the variable of interest except for loss of information about variance if the spatial aggregation process leads to a high within-unit heterogeneity. However, with randomly shaped spatial units, the distortions in data become larger, although averaged data does not suffer as much as summed data. After simulations Briant et al. (2010) turn to real world data and spatial units of different scales. They conclude based on French data that the size of the units is more important than the shape, with smaller units performing better.

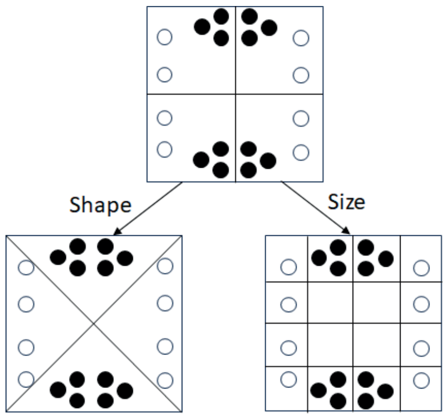

Figure 2: Illustration of the modifiable areal unit problem. Adapted from Briant et al. (2010).

Another work studies the error in transport costs when smaller spatial units need to be combined to larger units for analysis (Tveter et al., 2022). With simulated data, they show that the error in transport costs is minimized when smaller spatial units are combined to larger ones through harmonic mean.

The suggestions from the MAUP literature for estimating labour market outcomes of transport projects can be summarised to three key points: (1) data should be spatially disaggregate and the spatial units should be small and uniformly shaped, (2) when combining spatial units for analysis, one should use the harmonic mean for transport costs, (3) the distortions from MAUP are of second order when compared to problems from wrong specifications of the empirical models.

3.3 Data requirements

3.3.1 Individual- and firm-level data

The data requirements for evaluating the effects of transport projects on labour market outcomes are substantial.[12] Firstly, individual-level panel data is necessary to enable a thorough evaluation of the effects and to account for factors such as changes in migration behaviour. For example, Heres et al. (2014) have shown that transport projects can result in selective migration, and failing to consider this can lead to biased conclusions about the project's effects. Additionally, individual and firm-level panel data offer the opportunity for a broader examination of both the mechanisms and effects, as demonstrated by Gibbons et al. (2019).

Secondly, the data should include precise information about residential or business location, for example, at the 250x250m grid-level or even at the building-level. If the location is at the municipal level, there are as many observations as there are municipalities in the sample (when accessibility changes

[12] This section is partly based on Metsäranta et al. (2019).

occur at the municipal level), resulting in low statistical power due to the small number of observations. More detailed data, such as at the grid level, significantly increases the number of observations, or statistical power, and allows for a more accurate measurement of accessibility.

Thirdly, information about the impact of transport project on accessibility, such as commuting time and cost, is needed to examine the project's effect on labour market outcomes.

Fourthly, data spanning a long period is required. When comparing different areas or cities, it's important to demonstrate that the research design is credible and that the areas have followed the same trends over time, such as employment, for an extended period. Additionally, areas need to be monitored for years after the project to capture all potential effects. Data covering a broader area also enable the assessment of displacement effects.

Statistics Finland has datasets that meet these needs. The FOLK modules (formerly FLEED) contain individual-level panel data, providing comprehensive information on skills (such as education) and employment (such as workplace and annual earnings and income). These data enable to control for both observed and unobserved characteristics of the workers. Data on firms is available, for example, from Statistics Finland's financial statements statistics, and municipal workplace statistics include information such as the industry of the workplace, turnover, and number of personnel. Using workplace-level data enables the use of a more comprehensive productivity measure and to control for observed and unobserved productivity differences at the workplace level (see, for example, Gaubert, 2018). Additionally, it is possible to obtain location data for both the individual's place of residence and workplace at the grid level (250x250m), and in some cases, even at the building level from Statistics Finland.

3.3.2 Accessibility data

Transportation network and changes in it can be measured in various ways. Number of public transport stops in an area, the length of road network in an area or changes in them are some of the simpler ways to describe the transport infrastructure in an area. However, these measures neglect important features of transport infrastructure.

First, transport networks are used by people to reach activities that people wish to do (Jones, 1979). Therefore, to fully assess the importance of a change in a transport network, a researcher needs to measure how the change affects the ease of reaching different activities. Second, measures that concentrate only on the transport infrastructure cannot be used to study policy interventions such as congestion charging or decreases in speed limits. Third, measures that concentrate on one travel mode neglect mode choice, which may be an important determinant for impacts on travel. For example, the public transport network has economies of scale for travellers where every additional traveller makes it more profitable to add service, which then improves the travel times of everyone using public transport.

Accessibility or market potential measures provide a unified framework for assessing the effects of different kinds of transport projects. These accessibility measures take the form:

$$A_i = \sum_j O_j f(\tau_{ij}), \quad (1)$$

where i and j indicate areas, A_i is the accessibility of area i, O_j is a size measure that indicates the importance of the area such as number of workers, number of residents or wage sum. Finally, τ_{ij} is a measure of transport cost, such as travel time or generalised cost of travel that can consider the pecuniary cost of travel and how different travel modes affect the cost of travel. The weight that a worker, resident or other measure of importance in area j has to the accessibility of area i is mediated by the decay function $f(\tau_{ij})$. This function is typically chosen to be the inverse of the travel cost, $f(\tau_{ij}) = \tau_{ij}^{-\alpha}$, or the exponential function, $f(\tau_{ij}) = \exp(-\beta\tau_{ij})$. The parameters α and β control how quickly the importance of places fade as a function of the transport cost. Researchers have taken different approaches to the choice of these parameters. A typical assumption is that the parameter for the inverse function is $\alpha = 1$ (for example, Gibbons et al., 2019). Other authors have estimated these parameters with gravity models using travel diary or commuting flow data, as the accessibility measure has a gravity model like appearance. The parameter is then interpreted as the coefficient for the travel cost in the gravity model (see, for example, Lee (2021) for the exponential function and Graham and Melo (2011) for the inverse function). Knudsen et al. (2022) calibrate the parameter in their exponential decay function by maximizing the coefficient of determination of their wage equation.

Specific care should be paid to the choice and construction of the transport cost τ_{ij}. In some applications where modal choices do not play a large role, the researcher may be able to use travel times from a certain dominant mode, usually the car, as the travel cost between areas. These situations can come up when the research considers inter-city travel, or other national travel, where the mode share of car travel can exceed 90 % when the length of the journey grows. In other cases, the inclusion of alternative modes including their travel times and pecuniary costs are crucial. This is especially true in cities that have sizeable mode shares of public transport, cycling and walking, and when the transport project of interest concerns other modes than the dominant one. The importance of accounting for congestion in the travel times is noted by Graham (2007b) and Graham and Dender (2011).

Most studies use the travel cost of a single mode as the travel cost between areas (Knudsen et al., 2022; Gibbons et al., 2019; Graham, 2007b), but some have included other modes into the transport cost as well (for example, Börjesson et al., 2019). Combining different travel modes into a single transport cost measure is achieved by a weighted sum of all travel costs. In Börjesson et al. (2019) the generalised cost for each mode is first calculated in monetary terms by weighting the travel time by mode with a value of travel time savings for the mode in question. These costs are then aggregated to a single cost measure by a mode share weighted sum.

Another suggested way of aggregating multiple modes to a single transport cost measure is the use of the inclusive value from a logit mode choice model as the cost measure. In the context of random utility models this value is the expected maximum utility that an agent receives from a choice (Cascetta, 2009). These types of measures are typically present in structural models of transport (for example, Tyndall, 2021; Allen and Arkolakis, 2022), but not extensively used in reduced form work.

3.3.3 Data sources in Finland

Possible data sources for Finnish research vary depending on the region in Finland. Data about the transportation networks can be found for the whole country, but more sophisticated tools such as travel demand models are currently only available for certain areas.

Transport networks. The Finnish Transport Infrastructure Agency (Väylävirasto) also provides open data about the transport network in Finland. They provide a map service and several APIs through which it is possible to access a plethora of information about the road, rail, water and air transport networks (Finnish Transport Infrastructure Agency, 2024). The oldest snapshot of the road network is from 2019. The Finnish road network also hosts traffic measurement points that monitor the traffic volumes and speeds at over 450 places throughout the road network. This data is provided in real time as well as historical records of the measurements. It is also possible to access the raw data from these measuring points that includes every measurement that has been made (Fintraffic, 2024b).

Data about the public transport network and timetables is provided in General Transit Feed Specification (GTFS) format. Finnish GTFS data is scattered across providers, but is usually provided by city authorities, as in Tampere, or a city's public transport authority, such as HSL in Helsinki region or Föli in Turku region. National Access Point that is managed by Fintraffic gathers the sources of GTFS information from all public transport providers to one searchable database (Fintraffic, 2024a). Historical GTFS data is also available. For example, GTFS feeds of the Helsinki region can be found from 2016 onwards.

Travel times. Beside travel demand models that assess the number of trips, their modes, destinations and routes, there are tools to calculate travel times for trips by a certain mode. Tools such as OpenTripPlanner (OpenTripPlanner, 2024) and GraphHopper (GraphHopper, 2024) are routing tools that can use open source transport network data from OpenStreetMap to calculate fastest routes and travel times between given coordinates. To provide public transport routes and travel times, these tools use the commonly available GTFS data. Digitransit is a routing service that has collected the different GTFS feeds in Finland to provide a routing service for public transport (Digitransit, 2024). They also provide an API to make these routing requests programmatically. Also, Google Maps and Bing Maps provide routing services that can be used in calculating routes and travel times between coordinates. These routing tools are useful in calculating travel times between areas and Google Maps API can even consider congestion based on historical traffic information.

A further resource for travel times in the Helsinki region is the Helsinki Region Travel Time Matrix that has been produced by a research group in Helsinki University (Tenkanen and Toivonen, 2020). This travel time matrix contains the travel times by walking, cycling, public transport and car for the years 2013, 2015 and 2018 between all Statistics Finland 250x250m grid cells. The travel time matrix contains travel times for the rush hour as well as midday. For each mode, the travel time matrix also considers additional journey related time costs such as unlocking/locking time for bikes, waiting time at home for public transport and parking for cars.

Travel demand models. Some areas such as Helsinki, Tampere and Turku region have travel demand models that can be used to model the effects of transport projects on travel times. The Helsinki region travel demand model is the only model that has been extensively documented (Pastinen et al., 2020) and information about other models is scattered across different documents. The use of these models requires a license for proprietary software as the route choice models are typically handled by third party software such as EMME or VISUM.

The Finnish Transport and Communications Agency is developing a national travel demand model system, which can be used in assessing the transport related effects of transport projects in the whole country (Traficom, 2024b). The model system is supposed to make use of the local travel demand models and form a comprehensive system of different travel demand models for intra-regional and inter-regional transport forecasting and analysis.

Travel surveys. Travel surveys are an excellent source of information about individual travel behaviour. Three main travel surveys are conducted in Finland. The national travel survey that is managed by Traficom (Traficom, 2024a), the Helsinki region travel survey that is managed by HSL (HSL, 2024) and the Helsinki city travel survey that is managed by the City of Helsinki (for example, Ronkainen, 2024). As the names suggest, the national travel survey surveys the whole nation and Helsinki region travel survey surveys the citizens in Helsinki region. These two surveys are conducted approximately every four years. The Helsinki travel survey however surveys only people living in Helsinki and is conducted yearly.

4 Remarks on transport policy

Research on the labour market impacts of transport projects is used to provide information about the effects of transport projects and policy. The main economic analysis framework for assessing transport projects is the cost-benefit analysis, which assesses the social profitability of a transport project through its effects on the transport market. As we have seen, transport projects have effects that occur beyond the transport market in labour markets. Recently, these labour market effects have also been under increasing interest among policy makers. In a context where cost-benefit analyses are used in analysing the rationale for projects, it is vital to understand the relationship between benefits that are assessed in the cost-benefit analyses and the outcomes that occur in labour markets due to said projects. As commuters trade off commuting time and wages, calculating benefits from increased employment and wages can lead to double counting of benefits if proper care is not exercised. Nevertheless, even if the social value of labour market benefits would be evaluated already in the cost-benefit analyses, estimates of the different labour market outcomes can be of interest to policymakers and planners for understanding which objectives certain transport projects might help with.

Using excessively high elasticity estimates in decision-making may lead to over-investment in transport infrastructure. For example, impact assessments based on too high agglomeration elasticities of accessibility may overstate the productivity gains from agglomeration.

Next, we will shortly review the use of cost-benefit analysis in transport project assessment and the problem of double counting labour market benefits.

4.1 Cost-benefit analysis

The economic rationale for a given transport infrastructure projects and its ranking among other transport investments is typically evaluated with cost-benefit analysis. The basic premise of cost-benefit analysis is to evaluate the project based on its consequences with the theoretical basis drawn from welfare economics (Boadway et al., 2006). Despite its widespread use, the use of cost-benefit analysis has also been debated partly due to the many ethical and theoretical decisions that are needed to arrive in such a framework. More complete treatments of cost-benefit analysis can be found from Drèze and Stern (1987) and Boadway et al. (2006) and summaries of the criticisms around the method can be found from, for example, Van Wee (2012) and Næss (2006). Here we concentrate on the practical use of cost-benefit analysis in evaluating transport infrastructure investments.

Typically cost-benefit analysis of transport infrastructure investments is done in a partial equilibrium setting, where only impacts that happen in transport markets are analysed. A model is used to compare a world with the analysed transport infrastructure investment to a world without. Transport infrastructure is durable, so the effects of the projects are appraised during many years. A typical time period ranges from 30 to 50 years (Sartori et al., 2014). Estimates of yearly benefits are usually assessed by modelling the start and end year of the assessment period and interpolating the benefits in the years between. The benefit calculations can be made more accurate by additionally modelling some years between the start and end years. Generally, impacts that are appraised in the process are the effects on time-savings, traffic safety, local pollution and noise, greenhouse gases, ticket revenue and operating costs of public transport and maintenance costs of infrastructure (Sartori et al., 2014). The effects are monetised with unit values that can be derived from, for example, revealed or stated preference experiments, mitigation or damage costs, costs of meeting targets or hedonic prices (Koopmans and Mouter, 2020). The monetised benefits of completing the project are then compared to the costs of investment and if the benefits exceed the costs the project is deemed socially beneficial. This rather simple cost-benefit test is derived from the Kaldor-Hicks principle which states that if the beneficiaries from a reallocation of resources could compensate those who suffer, in a way to make the reallocation a Pareto improvement, the reallocation is socially beneficial.

The Finnish transport governance uses cost-benefit calculations to inform officials and politicians about the social benefits of transport investments.

Väylävirasto publishes manuals and unit values for the cost-benefit analyses of transport projects. The manuals consist of a general assessment manual and several manuals that consider certain types of projects such as road, rail, rail yard or waterway projects (Finnish Transport Infrastructure Agency, 2018). Additionally, the Finnish Transport and communications agency Traficom has published a manual for the assessment of light rail and metro projects in urban areas. These manuals are updated regularly and the transport governance has also invested in research to develop assessment methodology and tools for appraisal (for example, Liikenne- ja viestintäministeriö, 2020).

Väylävirasto also maintains the unit values for cost-benefit analyses. These unit values are assessed with a combination of statistical analysis, existing literature and governmental reports. For example, the values of travel time are based on the average wage in Finland, and its travel purpose-based variation is derived from Swedish value of travel time studies. (Metsäranta et al., 2020)

4.2 Labour market impacts and the risk of double counting benefits

Increased economic activity and labour market effects are natural candidates for benefits to be evaluated in a cost-benefit analysis of transport projects. Transport projects might decrease unemployment if reduced commuting time encourages workers to extend their job search range or accept work from employers further away (Manning and Petrongolo, 2017) or increase wages if productivity rises due to, for example, agglomeration effects (Redding and Turner, 2015). Nevertheless, researchers need to be careful which benefits they use in conjunction with each other, as changes in the transport market capitalize in other markets such as real-estate and labour markets, leading to the possibility of double counting some benefits. Models of commuting and employment posit that on the margin, people trade off commuting time and wages (for example, Eliasson and Fosgerau, 2019; Manning and Petrongolo, 2017). Thus, the value of reduced commuting time already measures the welfare effects of increased employment through the transport investment and including benefits from increased employment would lead to double counting of these benefits.

However, all benefits from decreased travel time would be assessed through the value of travel time savings only in perfect and competitive markets. The connection between transport and labour markets is not perfect. Venables (2007) show that decreased travel time can induce agglomeration benefits and increased tax revenue that are external to people's commuting decisions and thus not considered in their value of travel time savings. This result has consequently sparked a literature that has tried to estimate these external agglomeration benefits to incorporate them in cost-benefit analyses (Graham, 2007a,b; Börjesson et al., 2019; Knudsen et al., 2022).

Unfortunately, incorporating these results to national guidelines has been slow, as the risk of double counting exists even with the aforementioned estimates. As mentioned in Section 2.1, Duranton and Puga (2004) divide agglomeration benefits emanating from three different channels: (i) matching, (ii) sharing and (iii) learning.[13] The difficulty of incorporating agglomeration

[13] Matching referring to more productive matches between firms and workers, sharing to the possibility of sharing indivisible facilities or intermediate suppliers, and learning to the

benefits into cost-benefit analyses stems from the fact that as described earlier, workers take the effect of matching into account when making commuting choices, and firms most likely experience the benefits of sharing through, for example, smaller logistics costs that, in turn, are represented by travel time savings of vans and trucks in cost-benefit analysis. Therefore, only learning benefits are left as external for the choices of travellers. Separating different mechanisms of agglomeration has been under research but has mostly concentrated on showing the relevance of each mechanism to the benefits of agglomeration (Combes and Gobillon, 2015). Recent efforts have produced estimates that leave matching effects out of the estimates by concentrating on accessibility between workplaces (Börjesson et al., 2019; Knudsen et al., 2022; Haapamäki et al., 2024). Benefits that are assessed with these estimates can plausibly be added to cost-benefit analyses that do not account for travel between workplaces. Nevertheless, the question remains how to incorporate agglomeration benefits to cost-benefit analyses in settings where travel time savings for travel between workplaces is assessed. Hence, the work to include agglomeration benefits to cost-benefit analyses without double counting is still underway. However, the taxes from increased wages due to transportation projects could already be added to the analyses.

5 Discussion

We have reviewed existing theoretical and empirical evidence on the effect of transport project on labour market outcomes. The general message based on

dissemination of knowledge and best practices.

this evidence is that each project has unique effects on labour markets. In the context of developed countries with matured transport systems, the effect of a single transport project is typically incremental. Also, transport projects that seemingly improve the transport system can still have negative consequences on labour market outcomes such as city employment.

For decision-making and planning purposes, the uniqueness and ambiguous direction of impacts of a single transport project highlights the need for accurate understanding of the underlying mechanisms that connect labour markets and transport markets. The *ex ante* assessment of these impacts also requires good tools and methods so that transport projects can be designed in a way that they reach their intended goals. Also, advances are required to incorporate labour market benefits that are external to travellers to the cost-benefit analyses of transport projects.

Thus far Finnish research on labour market effects of transport projects has been scarce and mostly confined to governmental and technical reports. However, possibilities for high-quality peer-reviewed research on this subject exist in Finland. Accurate individual-level data on labour market outcomes is available from Statistics Finland for research. Cities, public transport authorities and governmental institutions provide high-quality data about the transport networks in Finland. However, lack of data about historical transport networks can pose a challenge to some examinations. Although records of older transport networks exist, earliest open-source versions tend to be from mid-2010's depending on data source. Most data that are provided concerns the current state of the transport network, with little information about its state in previous years. This means that constructing, for example, differences in travel times between different time periods may require substantial work to reconstruct the transport networks from previous years, or some specific data sets such as the Helsinki region travel time matrices (Tenkanen and Toivonen, 2020).

The existing research on transport projects' effects on labour markets mostly considers settings where new transport infrastructure is built, although some related work considers loss of access due to political restricions (Ahlfeldt et al., 2015; Redding and Sturm, 2008). Transport network failures due to, for example, natural catastrophes have been used more in examining transport outcomes (for example, Zhu et al., 2010; Xie and Levinson, 2011) than labour market effects (for example, Tyndall, 2017), and could be an interesting avenue for research also in labour market impacts. However, the temporary nature of these disruptions might prove to offer too short of a period for changes to take effect. A similar avenue would be to study conscious decisions to dismantle some transport infrastructure by, for example, shutting down rail stations or other downgrades of public transport routes. However, compared to natural transport network failures, these settings may suffer from similar endogeneity problems as construction of new transport infrastructure. Moreover, more research efforts should be targeted towards how the labour market gains from transport improvements are distributed across workers and how they impact income inequality and the gender wage gap following the work by, for example, Bütikofer et al. (2022).

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