Accessibility of labour

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Contents

1 Introduction

Aim of the thesis is to find the accessibility estimates of how an individual firm benefits from a worker. Now the estimation is done in terms of how workers benefit from the firms. These different estimations could then be assessed side-by-side to see if there is any significant difference. In a larger picture the aim is to find out the impacts of transport investment on labour accessibility and how these impacts should be quantified.

Further more in the thesis the intention is to find out the impacts of transport investment on labour accessibility and how these impacts should be quantified. The data estimation is done in the context of Helsinki regional area to find the differences between benefits of individual workers and individual firms in terms of accessibility.

Labour supply effects can be divided roughly on participation and employment effects. Participation effect means that an individuals labour force participation decision is an optimisation problem between costs of working, including commuting costs, and the wage (Venables, 2017). Employment effect is related to people moving to higher paid jobs, thus increasing their tax revenue in the perspective of the government.
Transport investment has an impact on economic performance, the expectation is that the transport investment acts as a catalyst on private investment, creates jobs, boosts economic activity and all in all seen as a channel for growing the local or national economy (Venables, 2017).

Transport is needed for the functionality of the labour market, as transport enables a larger area for employees to find work. The purpose of transport investment is to enhance the performance of the labour sector. Transport means that there is better matches of firms and employees, which allows for more and better specialisation for employees. Specialisation in individual terms means more wage, which means that the tax revenue increases in national terms. This connection justifies transport infrastructure investments.

The cost-benefit-analysis (CBA) is a typically used framework in economic appraisal and transport infrastructure appraisal (Venables, 2007). In this framework it is easy to compare static comparative equilibriums the "with" and "without" states of the world, when all else is held constant (Mackie et al., 2011). In an ideal world, we would like to model all of the impacts on an individual and society level. In practice, the CBA framework is partly in monetary terms, partly in physical impacts and partly in descriptive terms. That is why conventional measures of welfare changes need to be applied with strong element of judgement (Mackie et al., 2011).

The wider economic impacts (WEI) are harder to measure in the traditional CBA and they are usually considered to be impacts that go beyond the consumer surplus. WEIs are hard to take into account in traditional CBA as impact assessment tend to concentrate on areas where economic activity has expanded, in the expense of the areas where it has been displaced (Venables, 2017). This displacement effect is one of the key factors, why the CBA framework is not the best fit for transport infrastructure appraisal. The local effects and national effects are different and need to be addressed differently in the decision making.

Direct impacts are quantitative and rather easy to measure. Those ones contain the time savings of the improved transport, more efficient mobility and the enhancing effect of the improved transport to productivity (Laakso et al., 2016). Easier access to the centre causes the equilibrium employment to increase in the city (Venables, 2007). The direct impacts mean that the area where workers might live gets bigger and all in all it means that the labour force of the certain area is bigger. Additional employment in certain areas therefore also raises the productivity of existing workers, who now reap the benefits of larger urban agglomeration (Venables, 2007).

The components of direct transport benefits are time related (time savings and reliability) and money related (vehicle operating costs and out of pocket costs/fares/tolls).

Wider impacts are driven by accessibility changes and these changes are dominated by changes in travel time (Mackie et al., 2011).

Indirect impacts are characterised as wider economic impacts or externalities based impacts. The indirect impacts are a little harder to measure, but usually the effects should be emphasised a little more in the decision making of transport investment. These impacts are agglomeration benefits and the imperfection of the markets, this imperfection allows for the wider economic impacts to emerge (Laakso et al., 2016). Transport improvements typically increase the strength of agglomeration economies by increasing connectivity within the spatial economy (Melo et al., 2013).

After the introduction, I go through the literature in steps. The aim is to give understanding of the literature and go through the impacts from the narrow to the broader ones. Firstly, I examine the wider economic impacts and the labour market impacts in more detail, the emphasis is on the impacts on labour supply. The wider economic impacts are also referred as indirect impacts in the literature. I also build a short overview of the empirical literature and the results concerning labour supply. Secondly, I examine the cost-benefit analysis (CBA) as a framework on transport appraisal. This overview goes through the direct impacts of transport investment and the shortcomings of this framework to include wider economic impacts. Thirdly, I derive the logsums for accessibility changes, which can be used in the estimation of the data and to go through the different alternatives how we could measure these changes in the economic activity.

2 Literature and contribution

This section is dedicated on different literature concerning the subject and contribution of the thesis. The objective of this section is go from the narrow and specific impacts to more broader impacts and the evaluation of these impacts. The general thought behind justifying transport investment is the following. Improvements in transport mean a reduction in transportation costs and travel times. These effects mean that existing firms may serve larger market areas. Firms are able to increase their total output and reap economies of scale. This in turn is spread out to other sectors and regions through a demand-driven multiplier process (Oosterhaven, 1981).

Firstly, I go through the different urban economics model and how they influence transport infrastructure evaluation. Secondly, I go through the wider economic impacts and dwell a little deeper on the labour supply effects of transport infrastructure improvement. Also some empirical literature concerning labour supply effects is introduced. Thirdly, I provide the current framework used in transport infrastructure project evaluation (CBA). Fourthly, I will bring forth some points on how to develop current project evaluation framework and what is the current state of measurement of wider economic impacts concerning transport infrastructure improvement.

2.1 Urban economics models

The development of urban economics models from monocentric models to polycentric models. Because we are interested mostly on commuting costs and transport on individual and household level, this brief analysis of the urban models is restricted on these factors.

Monocentric cities expand around the central business district (CBD). The theoretical backbone of monocentric models comes from the work of Alonso et al. (1964), Mills (1967) and Muth (1969). The key observation of the model is that commuting cost differences within an urban area must be balanced by differences in the price of living space. This compensating price variation means long and costly commuting trips for suburban residents (Brueckner, 1987). In monocentric models, the key feature is also about the "consumption" of land, either directly or as an intermediate input in the production of housing.

In reality cities tend not to be monocentric, but rather to be polycentric. This means that the number of employment subcenters increase as the population and the commuting costs of cities increase (McMillen & Smith, 2003). In the research conducted by Fujita & Ogawa (1982) the spatial configuration of the city is treated as an outcome of the interactions between households and firms. Firms favour concentration as a reason for agglomeration economies and households follow the employment distribution. The main parameters are commuting and production level. The agglomeration economies is attached to the model via a concept of "locational potential" developed by Fujita & Ogawa (1982). Research has been conducted in relation to developing the theory of polycentric models even further as the monocentricity is not theoretically complete and in reality the urban land use pattern seems untenable (Fujita & Ogawa, 1982).

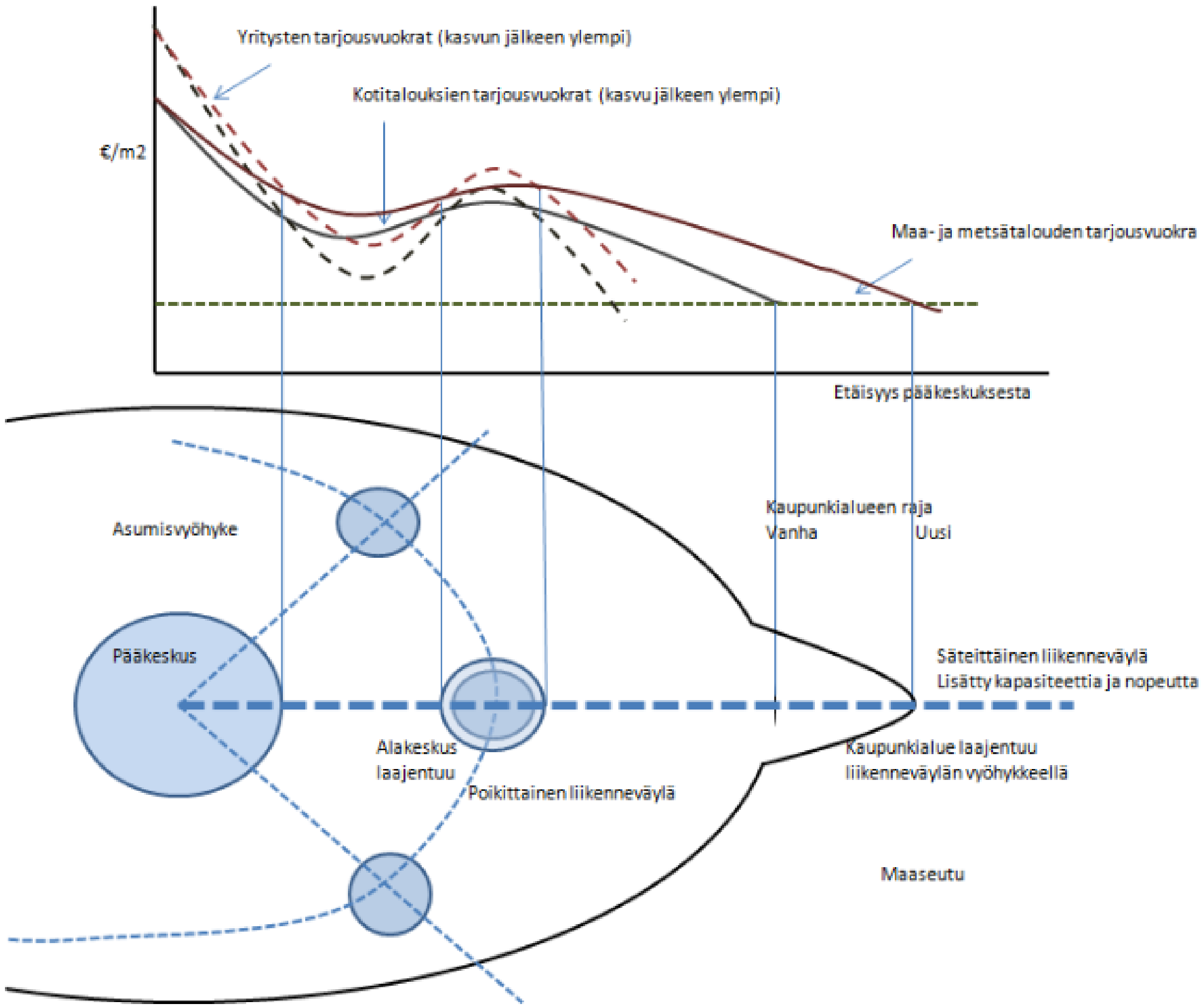

Figure 1: The bid rent curves of firms and households (above) and the land-use of the city with the development of transport (Laakso, 2015)

Figure 1 above shows the different bid rent curves of the firms and households and the land-use within the city, when the transport infrastructure is improved. As the bid rents and land-use changes are slightly out of scope regarding this thesis, I will not go through these changes too deeply. In the figure it is well depicted how the transport investment affects the subcenters of the city and the area of the city. (Laakso, 2015).

The monocentric and polycentric models are interesting regarding this thesis, because of the models implications on commuting costs and transport. In monocentric models the commuting is seen as a mean to enter the central business district (CBD). On the other hand in the polycentric models the economic activity is more divided on subcenters, but usually firms favour concentration because of the agglomeration economies. The figure discussed above has relevance in both the monocentric and polycentric models. Transport investment that is conducted in a radial traffic route, the willingness to pay for land increases relatively more as we go farther from the CBD. The accessibility of firms in the subcenter is improved in relation to the CBD. Thus the residential sector expands, which also means that the city expands on the traffic route, where the improvement was made (Laakso, 2015).

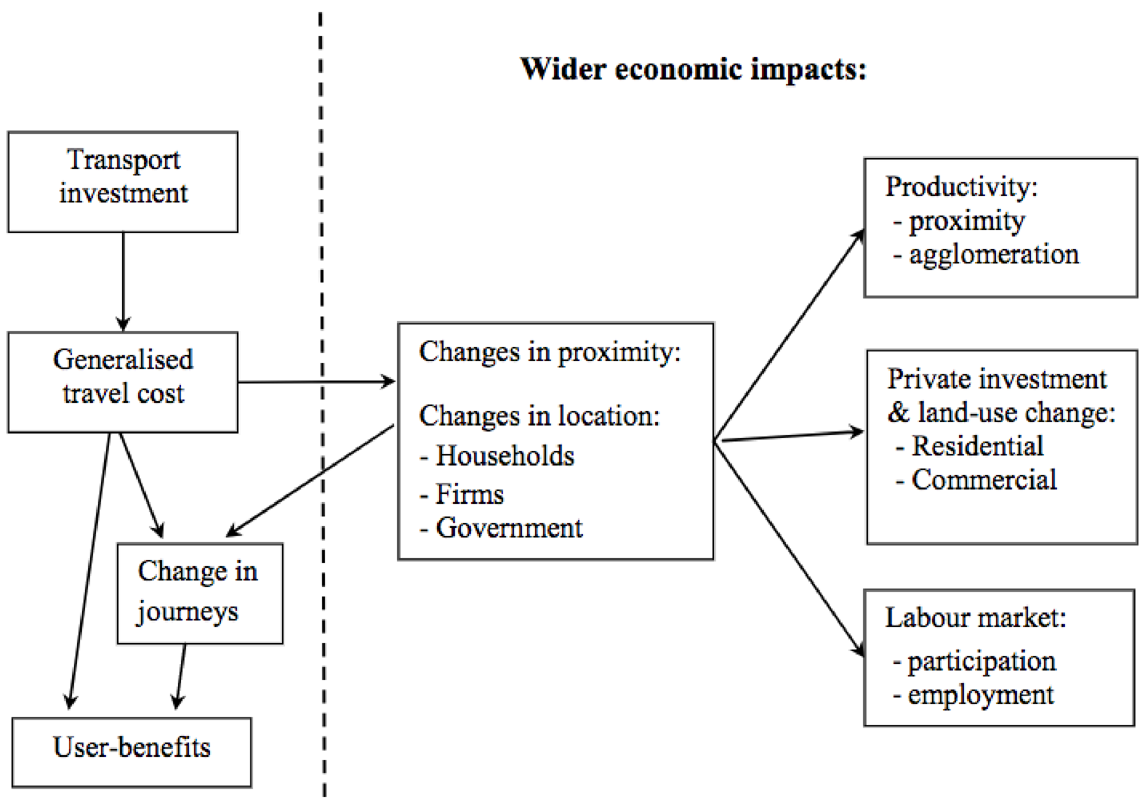

Figure 2: The effects of a transport improvement (Venables, 2017)

In the above figure it is shown how a transport improvement has a direct effect on the user-benefits through the generalised travel cost and change in journeys. User-benefits are the social values of transport (Venables, 2017). The investment affects the costs of transport. The generalised travel costs are a key ingredient on the user-benefits. The costs of transport affect the accessibility of different areas, which in turn influence the decision of positioning and the land use of firms, individuals and the public sector. The impacts are implemented in the traditional CBA (Laakso et al., 2016). These direct impacts have an effect on the wider economic impacts through productivity, private investment and land-use changes and labour market (Venables, 2017). The labour market outcomes are the most interesting regarding this thesis. Transport may enable labour market participation on the labour supply side and jobs will be created in some places and some activities, and possibly lost in other. The question of supply and demand for labour are intertwined. In this thesis, the labour supply side is emphasised (Venables, 2017).

2.2 Wider economic impacts

The wider economic impacts occur, because of transport improvement's impact on economic geography. The reasons why the transport improvement has wider economic impact is because of proximity and relocation of households and firms. The proximity and relocation affect the effective density of economic activity and productivity. These effects go beyond the direct productivity effects of faster journeys. There is strong economic interaction in dense places. This is why cities and agglomerations exist. There is substantial research that show the positive relationship between density and economic activity (Venables, 2017).

Transport investment also affects the locations attractiveness for other financial investment. User benefits are experienced by residents, workers and firms. The user benefits may activate the residential, retail and public investment. These impacts are also linked on agglomeration and productivity and have further value on the attractiveness of the location (Venables, 2017). The improvement may also have an effect on the labour market, both in supply and demand. On the next section we go deeper on the labour market effects.

There are unaddressed questions on how to include the wider economic impacts on transport appraisal and should they even be included. These questions are related on market failures, the displacement effect and the quantifying and predicting of the effects (Venables, 2017). Firstly, market failures means that the transport improvement creates additional benefits or costs. Additional meaning here benefits or costs that go over and above the user-benefits. Secondly, displacement of some work from local areas need to be taken into consideration on national aggregate level. When concentrating on national aggregate level, the view of the appraisal is more complete. Thirdly, as a single transport project has complementary effects on other transport projects, land-use and other policy changes. It is not feasible to believe that even the larger projects have transformative effects, though it is usually claimed as so (Venables, 2017).

The wider economic impacts are the most interesting when thinking of accessibility of labour. These impacts are also the ones that are constantly under estimated. As Laakso et al. (2016) say in their report to Finnish transport agency that especially the wider economic impacts are hard to take into consideration in the decision making considering transport investments. That is why an estimation of the distance function and a literature review on the accessibility of labour would have an impact on the way transport investments effects are measured in the future (Laakso et al., 2016).

2.2.1 Labour market impacts

The transport investment may have an effect on the labour market in two different ways. Firstly, through agglomeration economies, which is made clear by the fact that productivity grows with city size or density. (Andersson et al., 2015) This effect can also be described as labour market pooling as described by Marshall (1890) as a localised industry gains a great advantage from the fact that it offers a constant market for skill. This means that labour market pooling affects the matches made by individuals and firms, making these matches more productive. Secondly, the effect of transport investment on labour market comes through the labour supply in the economy given static housing market. A reduction in travel time and thereby travel cost may increase production, since more time is used in production rather than traveling (Andersson et al., 2015). Of these two labour market effects, the labour supply effect is the more interesting effect regarding this thesis.

Income taxation provides some inefficiencies in the labour market, which may have implications for evaluating transport projects. Individuals make their choices on after tax income, but the individuals' production value for society is reflected in before tax income (Andersson et al., 2015). As Venables (2007) develops a model where the employees make their decisions on where to live based on the trade-off that wages are higher in the cities and the cost of commuting. Intuition behind this trade-off is that there is a tax wedge between the extra income earned by living in the city and the cost of commuting. The conclusion of the research is that the total benefit of reducing commuting costs may be several times larger than the reduction in commuting costs with some remarks and assumptions (Venables, 2007).

Pilegaard & Fosgerau (2008) formulate a spatial computable general equilibrium (SCGE) model with labour market search imperfections leading to unemployment. In this framework Pilegaard & Fosgerau (2008) show how substantial welfare effects are omitted when evaluating the effects of a transport improvement. It should be noted that in the framework of Pilegaard & Fosgerau (2008), there is no income taxation and the main focus is to show how traditional CBA underestimates the impact of transport projects (Andersson et al., 2015).

2.3 Empirical literature concerning labour supply

Most of the empirical literature considering labour supply measures the elasticity of labour supply with respect to the wage rate. The most important aspect regarding labour supply and transport investment is to examine the causal effect of travel time on labour supply (Andersson et al., 2015).

The elasticity of labour supply with respect to the wage rate has an important role in economic policy analysis. Larger elasticity of labour related to a change in tax rate corresponds to a higher excess burden of taxation (Evers et al., 2005). The empirical estimation done by Evers et al. (2005) is not a perfect fit to the research question concerning transport infrastructure and labour supply. All though taxation provides inefficiencies on the CBA and thus is a relevant aspect.

The most important aspect regarding transport infrastructure investment and labour supply is to examine the causal effect of travel time on labour supply (Andersson et al., 2015). The causal effect might be too excessive goal to find in this thesis. More relevant is to take the first steps and assumptions related in accessibility improvement of labour supply.

Gutiérrez-i Puigarnau & van Ommeren (2010) introduce a theoretical labour supply model, which is then estimated to find out the effect of commuting distance on labour supply. The authors use a worker fixed-effects approach.

The results indicate that there is little variation on the workdays of worker, but much more variation on the daily work hours and also the effects of commuting costs on labour supply may differ by gender (Gutiérrez-i Puigarnau & van Ommeren, 2010). This means that workers mainly increase the total labour supply through the increase on daily hours.

The estimated positive effect is in line with the theoretical labour model. One possible explanation for this stated effect is that workers reduce commuting costs by coming earlier to work or departing later, this is in line with bottleneck economic models (Gutiérrez-i Puigarnau & van Ommeren, 2010). In this empirical research the fundamental assumptions are that workers may choose their daily labour supply and number of workdays (Gutiérrez-i Puigarnau & van Ommeren, 2010).

Same authors also measure the effects of how the commuting distance effects workers' work effort. The length of the commuting distance affects productivity through absenteeism and by workers evading responsibilities. The aim of the empirical research is to identify the effect of distance on voluntary absenteeism. There is a need for controls for subjective and objective health indicators as we are interested on voluntary absenteeism (Van Ommeren & Gutiérrez-i Puigarnau, 2011).

In Andersson et al. (2015) the methodology used to estimate the effects of transport improvement on labour supply is presented. The additional value generated is calculated by using general elasticity of labour supply and generalized transport costs (GTC). There exists three possible problems with this approach. Firstly, the travel time savings are dependent on precision of chosen transport model. Secondly, GTC is based on value of time that is calculated from stated preference studies. In these studies it is unclear if the value of time is taken before or after taxes. Thirdly, the use of single labour supply elasticity may cause heterogeneity, which calls for an area specific elasticity of labour supply (Andersson et al., 2015)

2.4 Transport investment cost-benefit analysis

Cost-benefit analysis is useful in quantifying the effects of a project and its distributional impacts, that is why it is the primary tool for evaluating transport projects. The evaluation is done through the costs of maintaining the passage (building and maintenance costs) and the monetised net benefits (Liikennevirasto, 2017). In the cost-benefit analysis framework, the key is to find those projects that are potential pareto improvements, meaning that winners should compensate the losers to obtain unanimous consent (Small et al., 1997).

The most important aspect of measuring costs and benefits is the willingness to pay, which means how much an individual is willing to pay to change his/her circumstances.

In transport investment the willingness to pay can be extended to travel time savings (Small et al., 1997) The travel time savings can then be used to derive the consumer surplus of particular improvement to transportation. The aggregate benefit would be measured by new users $Q_1 - Q_0$, who are willing to pay almost the full cost reduction (cost reduction being the reducing of waiting time for transport), lowering the full price from C_0 to C_1) $C_0 - C_1$ to those new users that are indifferent. The aggregate benefit to new users is demonstrated by the triangular area ABF in the figure below. The consumer surplus would increase from GAC_0 to area GBC_1 in the same figure (Small et al., 1997).

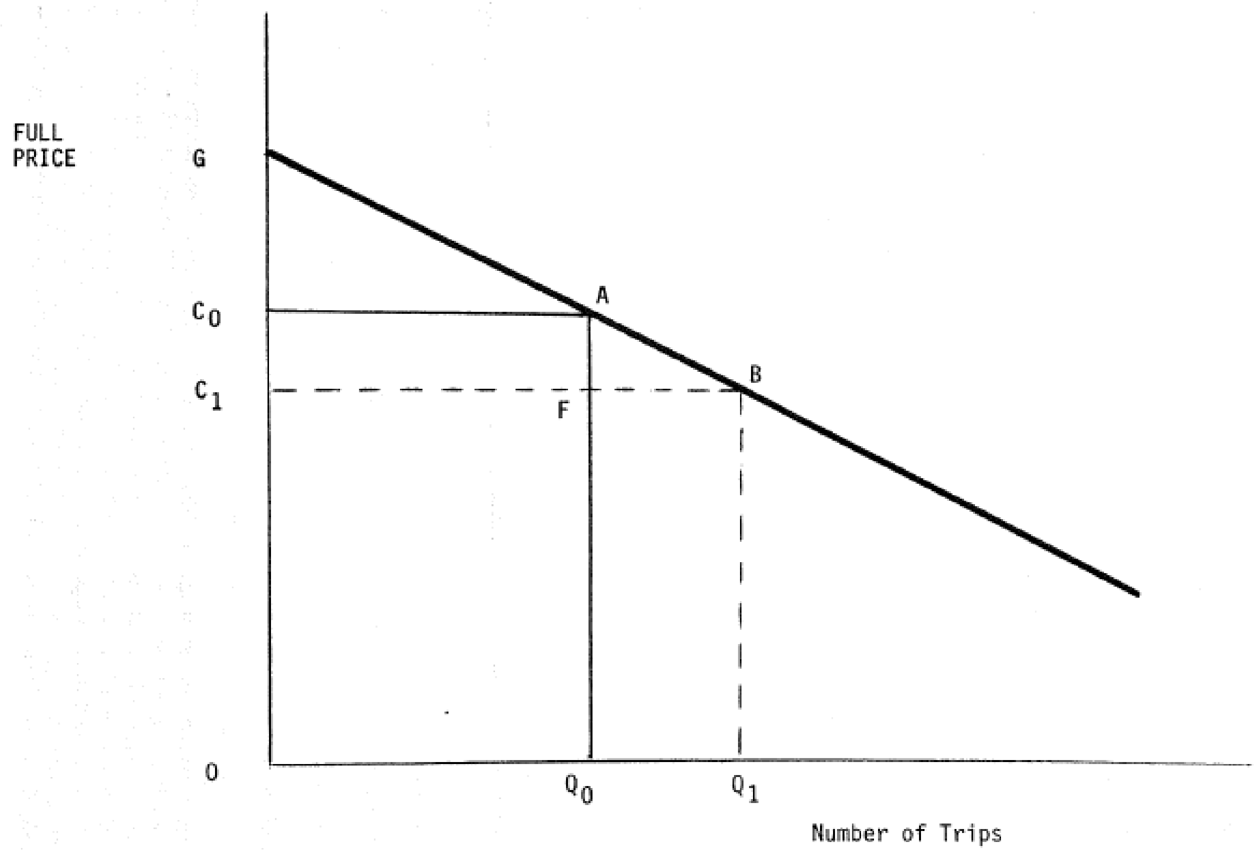

Figure 3: Benefits to existing and new users (Small et al., 1997)

In the figure, the area ABF is approximately triangular. The triangle is thus equal to half of the number of new users multiplied by the reduction of full prices. This estimation is known as the rule-of-one-half (RoH). The principle greatly simplifies the estimation of benefits to new users as the estimation of the demand curve is not needed, but only the number of new users and cost savings to existing users (Small et al., 1997). The RoH estimation has its critiques. As mentioned in Geurs et al. (2010) when RoH is used as a practical assumption of consumer surplus, a number of assumptions are made that do not generally hold. Firstly, the assumption that the demand function is linear, which is usually true only for new infrastructure projects. Also the changes in generalised costs should be regarded as marginal if the changes in demand are large. For example, in some traffic reduction measures RoH can lead to significant errors (Geurs et al., 2010). Secondly, the benefits of accessibility accumulating to economic agents should come from the generalised travel costs changes within the transport system with respect to rule-of-half estimation (Geurs et al., 2010). This assumption becomes problematic when thinking of the wider economic impacts as well as the direct impacts.

In CBA it is hard to grasp the full picture of economic activity as the values placed on accessibility changes by individuals may differ from those of the society (Andersson et al., 2015). One answer to this problem is as Venables (2017) proposes in his research about the full economic modelling exercise, where all resource constraints are properly imposed, private sector responses modelled, market imperfections are made explicit and real income (utility) benefits accurately calculated. This could be done on large enough projects, but it is not a general solution. Another solution is spatial computable general equilibrium analysis (SCGE), which relaxes the partial equilibrium assumptions by modelling the surrounding economy. It has been stated that spatial computable general equilibrium (SCGE) models offer the chance of computing the wider economic impacts theoretically in a more satisfactory way. (Andersson et al., 2015). All in all, the market imperfections are the most interesting impacts relating to the accessibility of labour. This is why there is a need to develop a framework where the wider economic impacts of different aspects of economic activity can be quantified and applied in appraisal (Venables, 2017).

In Finland, the Finnish transport agency has researched the evaluation of transport routes costs and benefits. The impacts of travel-time, accidents, noise, emissions and the operating costs of different vehicles (cars, trains, buses and so on) are analysed. These impacts are then multiplied by the designated estimated unit values. These unit values have been derived from the market or from valued prices (Liikennevirasto, 2017). This is the technical measurement of the cost-benefit analysis, which is used widely in transport infrastructure analysis. If the benefits and savings are larger than the investment, then the cost-benefit ratio is over one. Even if the cost-benefit ratio would be under one, the investment is not necessarily unprofitable. This is mainly because of the wider economic impacts. Usually in the project evaluation and cost-benefit analysis the agglomeration and labour supply accessibility impacts are left out from the evaluation (Goebel, 2016).

The Finnish transport agency has published a report on how to improve the project evaluation from Finnish viewpoint. There are five aspects that need the most attention in project evaluation in Finland. Firstly, other than work related travel-time savings and the re-evaluation of the road usage costs. Secondly, the valuation of emissions and accidents. Thirdly, the precision impacts of railroad evaluation. Fourthly, the use of mobile devices enables the utilisation of the travel-time in a more beneficial way, which means that the travel-time savings valuation decreases. Last point is about robotisation, which enables the better use of travel-time even in passenger cars. This would mean that public transport loses one of its most important competitive advantage (Goebel, 2016). The most relevant aspects for further research regarding this thesis are the first, third and fourth.

From this short overview, we can conclude that there is a need for a better framework in the case of transport infrastructure improvement appraisal. The cost-benefit analysis is not a sufficient tool for measuring the wider economic impacts. The wider economic impacts usually go beyond the project evaluation framework. The wider economic impacts are identified, but the evaluation of the wider economic impacts has not been instructed (Laakso et al., 2016).

There has been a rise of macroeconomic literature regarding economic impacts of transport as Andersson et al. (2015) conclude. There has been two types of approaches, either through the usage of production function or the cost function. These approaches should include the externalities better than the traditional CBA. The critique concerning production function based approaches is that the behaviour of economic agents is overlooked, the cost benefit approach is better in this regard (Andersson et al., 2015).

The scope of the analysis is the main difference between the production function approach and traditional CBA. This is because of the different angles of the approaches. According to Andersson et al. (2015) the production function is based on macroeconomic theory and on output elasticities with respect to transport infrastructure. Traditional CBA is based on microeconomic theory and on the time and cost savings and the externalities associated to transport. In traditional CBA it is hard to include wider economic impacts, in theory the case should be different in production function approach. The output elasticities estimates are spread out both in magnitude and direction. This means that the analysis is not so straightforward between these models regarding which of the approach to utilise in transport appraisal (Andersson et al., 2015).

The mindset of cost function approach and traditional CBA has more similarities. As stated by Andersson et al. (2015) in CBA the generalised transport costs (the direct costs and distance- and time dependent costs) are the source of benefits. In cost function the distance dependent costs are included as a variable in the estimation, thus creating some overlap between cost function and generalised transport costs. In theory cost function approach could be applied in the same sense as CBA to estimate the effect of infrastructure investment. If the same infrastructure project would be analysed by cost function approach and CBA. If the cost function approach would predict greater reduction in costs than CBA, the greater reduction of costs could be seen as the inclusion of wider economic impacts in the cost function approach. Main problem of this approach is the uncertainty of included elements in cost function and in generalised transport costs (Andersson et al., 2015).

2.5 Measurement of wider economic impacts

The research done by Melo et al. (2013) about the meta-analysis of empirical evidence considering transport investments and economic performance suggest that investments on transport produce strong economic benefits and foster growth. The purpose of the meta-analysis is to identify sources of systematic variation in empirical findings through statistical testing of various researches about the size of the different empirical estimates. These empirical estimates of the previous literature concerning the output elasticity of transport have been affected by two main estimation issues, which are simultaneity bias and omitted variable bias (Melo et al., 2013).

The logsum-model would have the form that is described by the equations below. Mainly the last equation that tells the monetary value of accessibility of a particular zone for different type of people and income groups(Geurs et al., 2010).

$$l_{piz} = log(\sum_j exp(\mu_p V_{pjiz})) \tag{1}$$

In the equation μ_p is the logsum coefficient for travel purpose p. V the representative utility, which in a simplified mode can be determined as stated below (Geurs et al., 2010).

$$V_{zijp} = \beta_p T_{zj} + \chi_{ph} ln(C_{zj} + \delta_p D_{pj} + ...) \tag{2}$$

Where T is the travel time, C the travel cost and D a variable representing the attractiveness of the destination zone (Geurs et al., 2010).

$$CS^L_{piz} = VoT_{ph} \frac{1}{\beta_p} L_{piz} \tag{3}$$

First the logsums are translated into travel times by the time coefficients β_p and next into costs by external values of time, VoT. This equation in total tells the monetary value of accessibility of zone z for a person of type i belonging to household income group h. (Geurs et al., 2010).

3 Methods and Data

The methods include a couple of different variations about how the accessibility of labour should be addressed. The alternatives are the effective density measurement, transport elasticity or logit choice models. Most feasible is the logit choice model and the logsum as a measure of consumer surplus. I'll go through these different alternatives briefly in the next section. Then I'll continue deeper to logsum and logit choice models.

3.1 Different methods used in project evaluation

One method would be the effective density measurement, which measures the commute by generalising the different travel time costs (Venables, 2017).

$$ATEM_i = \sum_j f(d_{ij})Emp_j \tag{4}$$

The equation says that location i's access to economic mass $ATEM_i$, is the sum of employment in all districts j. This is weighted by some decreasing function f of their economic distance to i, d_{ij}. All this means that if a place is near to other places with high employment, it will have high $ATEM$ (Venables, 2017).

$$Productivity_i = F(\sum_j f(d_{ij})Emp_j) \tag{5}$$

Second step is to link the locations access to economic mass to its productivity with the relationship stated above. There is substantial econometric literature to quantify this relationship and find functions F and f. Economic distance can be measured in different ways (distance, travel time, or generalised costs) and economic activity is usually measured through employment or other activity measures (Venables, 2017).

The effective density method is used mostly on productivity and proximity estimation. The link between productivity and density is quite well established in the econometric literature. One survey of literature finds that "doubling the size of the city will increase productivity by an amount that ranges roughly from 3-8 %." (Rosenthal & Strange, 2004, p. 2133). The effective density can be used also to measure different variables of economic activity. Thus the effective density could be modified to measure the effects of transport investment in employment.

Other method is the transport output elasticity following the equations presented by (Melo et al., 2013).

$$Y_{it} = g(Z_{it}, T_{it}) f(X_{it}) \tag{6}$$

In the equation Y_{it} is the private output of area i at time t, $f(X_{it})$ is the production technology using input factors, typically labour (L_{it}) and capital (K_{it}). Transport infrastructure is introduced as direct input factors or as usual by a Hicks-neutral technical term, which is captured in the term $g(Z_{it}, T_{it})$. Term Z_{it} is a function of external environment factor and T_{it} is the term of transport infrastructure. The most common functional form follows the Cobb-Douglas specification stated below (Melo et al., 2013).

$$\ln Y_{it} = \beta_L \ln L_{it} + \beta_K \ln K_{it} + \sum_z \beta_Z \ln Z_{z,it} + \beta_T \ln T_{it} \tag{7}$$

After the logarithms have been taken, β_T represents the elasticity of output with respect to transport capital and is obtained as a partial derivative of $\ln Y_{it}$ with respect to $\ln T_{it}$ (Melo et al., 2013). In this meta-study (Melo et al., 2013) the mean estimate of elasticity across several hundred studies is around 0,03, although there is considerable variation according to sector, country and technique employed by researchers.

3.2 Consumer surplus, logsum and project evaluation

Also the evaluating of the data could be done in a rule of a half (RoH) principle, this evaluates the change in user benefits as the sum of the full benefit to original travellers and half the benefit obtained by new travellers (Geurs et al., 2010). RoH principle is used more when we measure the consumer surplus, so it is not the best measurement to use, when we want to model wider economic impacts. In the measurement of wider economic impacts, the logsum approach might be better from Geurs et al. (2010) the logsum is defined as the intergral with respect to the utility of an alternative. It provides exact measure of transport benefits, assuming the marginal value of money is constant (Geurs et al., 2010).

Logsum can be based on consumer surplus or as a logit choice probability, both of these will be derived in this section. Logsum is a more robust way to model the transportation and choices. Logsum can be seen as a more common framework that cover more factors of mode and destination choices. These choices are different travel time and cost components, service quality and person and household attributes (De Jong et al., 2007).

In this section I go a little deeper on the aspects of the logsum as a method of formulating the logit choice probabilities and also as an interpretation of consumer benefits. In the literature review, the logsum was addressed as an indicator of value of time (VoT). As a method the logsum is seen as a mode and destination coefficient, which is then used in the data estimation later.

Following (De Jong et al., 2007) I give a short overview of the logsum in this section. The logsum can be seen as a mathematical accessibility measure of the whole transport system. For further review and more in depth overlook to discrete choice analysis can be found from the appendix, following the textbook of (Train, 2009).
Utility of a decision maker n from alternative j is divided in an observed and unobserved component (De Jong et al., 2007).

$$U_nj = V_nj + \varepsilon_nj \tag{8}$$

U_nj is the utility of the decision maker n from alternative j (n = 1,..N ; J = 1,..J)
V_nj = "observed utility"
ε_nj = unobservable factors that affect utility (De Jong et al., 2007).

In standard multinomial logit (MNL) model, with ε_nj i.i.d extreme value with standard variance ($\pi^2/6$) the choice probabilities are given by:

$$P_{ni} = \frac{e^{V_{nj}}}{\sum e^{V_{nj}}} \tag{9}$$

The denominator of the logit choice probability gives the logsum. The logsum gives the expected utility of choices for example the mode and destination choices that are most interesting for transport purposes (De Jong et al., 2007). In project evaluation logsum is used as an interpretation of consumer surplus.

In the field of policy analysis the person's consumer surplus is the utility in monetary terms that a person receives in a choice situation, also including disutility of travel time and cost. Provided that the utility is linear in income, the consumer surplus is the maximum utility received by the decision maker n from the best alternative(De Jong et al., 2007).

$$CS_n = (1/\alpha_n)U_n = (1/\alpha_n)max_j(U_nj\forall j) \tag{10}$$

α_n is the marginal utility of income and equal to dU_nj/dY_nj if j is chosen. Y_n is the income of the person n and U_n the overall utility of a person n. The division $1/\alpha_n$ translates utility into monetary terms.

If the model is a standard multinomial logit model (MNL) and utility is linear in income, which means that α_n is constant with respect to income. From this we get the expected consumer surplus (De Jong et al., 2007). Expected consumer surplus in standard logit model is simply the logsum.

$$E(CS_n) = (1/\alpha_n)\ln(\sum_{j=1}^{J} e_n^V j) + C \tag{11}$$

Consumer surplus is used primarily to compare the situation before and after the transport investment (De Jong et al., 2007). The benefits of the transport investment are the difference of the expected consumer surplus $E(CS_n)$ before and after the investment.

I'll mainly use the logsum as a logit choice probability indicator. This means that the expected utility of mode and destination choices are the most interesting for accessibility measures. In the data section I'll elaborate some more on how the logsum is used in this particular case.

As was stated earlier the RoH can be used in project evaluation, but it has a couple of major simplifications, this means that the RoH only applies to small cost changes and in cases where the demand curve is nearly a straight line. The simplifications mean that at best the RoH can be considered as a rough approximation of the real welfare changes. The real changes can be calculated more precisely by deriving them from the transport models, as in the logsum approach (De Jong et al., 2007).

The paper by (De Jong et al., 2007) has a short overview on the theoretical literature concerning logsum-approach. First the theoretical framework is constructed through Random Utility Model (RUM), this means that in the model there is no room for taste variation and income effect (De Jong et al., 2007).

In these models the overall utility (welfare function) can be expressed as a log of the sum of the exponentiated utilities of the alternatives (De Jong et al., 2007). This kind of approach is also followed in this thesis to find out the different utilities by mode and destination.

3.3 Data

The accessibility data is provided by HSL, the data has been collected by HSL (Helsingin Seudun Liikenne) using travel demand modelling system (EMME). The modelling system has generated travel times and travel resistance between areas and regions, which then can be applied to the case of labour accessibility. The data would then be used to estimate the logsum of utility of individuals like in the research conducted by (Geurs et al., 2010, p. 387). From the methods section there should be some information about the different effects on accessibility in other countries, which could then be applied to the case of Helsinki region.

The analysis of the data follows the guidelines that have been established by HSL in their research of Helsinki region transport choice models and estimation. These are called HESY ("Updating and testing of Helsinki region disaggregate choice models") (HSL, 2016) and HELMET ("Traffic Forecast Models for the Helsinki Region Commuting Area 2010") (HSL, 2011). Firstly I will introduce the choice model side of the data and how the data has been analysed in the case of Helsinki region by HSL. Secondly, I go through the traffic forecasting and estimation side in the Helsinki region. In the last subsection I will make an effort to tie these together and continue to my part of the data analysis.

3.3.1 Choice models

In the previous chapter I introduced the logsum, which is a logit choice model. Logsum is widely used in transport infrastructure evaluation. In this research (HSL, 2016)

4 Expected results

After the analysis of the data we would have some sort of efficient distance function for the Helsinki region data. This distance function then could be used in different projects. Also the evaluation of logsum as an accessibility measure with Helsinki region data.

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