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Stavanger region, Norway

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Does suburbanisation of employment imply less sustainable mobility? –
The effects of location policy on commuters' travel patterns in the
Stavanger region, Norway

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Abstract

This paper investigates the effects of the location policy of workplace on commute travel patterns, focusing on the analyses of travel time, distance and car use. The analysis compares the behavioural patterns of commuters who travel to the suburban area with those who commute to the semi urban area and the city centre. The analysis is based on the commuters' travel behaviour survey conducted among the workers in the Stavanger region between 2008 and 2009 and uses estimation of linear and binary logistic regressions. The results are consistent with existing research literature that workplace in the suburban area has influenced the propensity to have longer travel time, distance and car dependency. The study also indicates that commuters choose the means of transport which can produce low travel time.

1. Introduction

Various products of policy on spatial planning and land-use development have been implemented in different ways by many countries as an instrument to obtain positive impacts on sustainable urban mobility. As argued by urban and transport researchers that indicators of good location policy are not solely based on financial perspective but also need to consider its effects on commuters' travel pattern (van Wee 2002; Marshall and Banister, 2000). In this sense, commuters who are affected by a location policy may associate to substantial reduction in terms of their travel time, distance travel and the share of car use on one hand and increase of the share of public transport and non-motorized transport on the other side (Verhetsel and Vanelslander, 2009). Finally, an attempt to reduce congestion, energy consumption, air emission and other environmental problems are the aims through successful implementation of location policy (Næss and Sandberg, 1996; Banister et. al., 1997).

Previous reports from developed nations suggest that decisions to locate economic activities in certain area with good accessibility to reach nearest public transport stations and significant improvement of pedestrians as well as other transport facilities may generate positive impacts toward sustainable transport. For example, the Dutch government has implemented the A-B-C spatial policy on workplace to locate industrial firms with planned accessibility and transport infrastructure in the 1990s (van Wee and van der Hoorn, 1996).

In Belgium, the Mobility Plan for Flanders was considered as a good spatial planning by locating business parks near to bus and train stations which can stimulate alternatives for car commuters (Verhetsel and Vanelslander, 2009). Two studies from Norway reveal that relocation of firms in the suburban areas of Oslo was conducted as part of greater Oslo's urban planning to accommodate growing economic activities in the city and to reduce dependency on central location which has limited road capacity. This policy was based on the National guidelines for co-ordinated area and transportation planning of Norway which was issued in 1993 by Ministry of Environment and the Planning and Construction Act (see more details at Hanssen, 1995 and Aarhus, 2000).

Nevertheless, the impacts on commuters' travel behaviour seem to vary across policies. From the first case in the Netherlands, it seems difficult to conclude whether the A-B-C location policy in the Netherlands has advantages for better mobility. However, evidence from Belgium highlights quite successful story, because after implementation of the land-use policy, the Belgian commuters have less travel distance and substantially increased the share of public transport, in particular where the area has a very extensive public transport infrastructure with good accessibility to reach the stations. On the other side, employment suburbanisation in Norway has failed to promote sustainable mobility because the policy induced auto use around 16%, and the use of public transport decreased by around 15%. This case tends to be more obvious when the business location is developed with poor investment on public transport facilities (Aguilera et al., 2009).

The present study is-driven by quite similar issue discussed earlier-to examine the effects of land-use policy on commuters' travel patterns based on decisions made by the local authority to locate commercial parks in the suburban area of the Stavanger region, Norway, named the Forus area. As a response of rapid socio-economic development and spatial extension in the Stavanger region - partly due to its role as "the Petroleum

Capital of Norway”- the local authority has allocated as well as developed a certain amount of land with high employment density, which can be occupied by more than 1200 businesses and provide opportunities for more than 24000 professionals. This policy is also influenced by a belief that suburbanisation of employment in the Stavanger region may reduce dependency on central city, leading to substantial reduction of travel distance (and time).

The main goal of this paper therefore is to examine the effects of location policy on the behavioural patterns across commuters. In particular, the differences between commuters’ travel patterns that have office in the suburban area and those from other groups (the semi urban and the urban areas) are examined. Does the decision on suburbanisation of employment lead to increase of commuting travel time, distance and car use? In addition, which factors do determine car use?

Examining the impacts of location policy focusing on commercial activities towards sustainable mobility seems to be crucial for stakeholders of the region as Chapman (2003) states that:

“...it may be pragmatically and politically more acceptable to change policies in primarily employment areas, because the users of those areas may have fewer complaints about more intense development than residential users typically do”.

In addition, the results of this study may also gain rich information to frame the current problems and set up future strategies in the region to anticipate a better transport planning (Tennøy, 2010).

The paper is organized as follows. A brief literature review on the impacts of employment urbanization on commuting travel patterns in the next section is first elaborated. Next, the dataset and sample profiles are discussed. The results of analyses with respect to the average travel distance and time as well as the share of mode choice across commuters’ location group are then presented. This section also includes the analyses of commuters’ perceptions toward preferred transport mode. Effects of locations on commuting travel patterns are examined. Finally, the concluding section offers a summary of the study.

2. Literature review

It has been long recognized that many studies have investigated the impact of decisions on industrial zones in suburbs on commuters travel behavior and those efforts may be classified into three broad results. The first group of studies reported that the development of commercial locations in suburban and less urbanised areas seem to reduce pressure on central city, in particular if there is much better accessibility found outside the city centre. For example, Aguiléra et al. (2009), employing the Paris data reports that employment decentralization reduces dependency on the city centre and provides a better accessible network of work-home journey. Other evidence further show commuters’ trip chain, travel distance and travel time substantially reduced when policies to locate commercial firms in suburbs with a more planned road network and public transport facilities were implemented (Christopher et al., 1995; Buchanan et al. 2006). Employment urbanisation’s policy has contributed to decrease with respect to the average distance of home-to-work trip, especially for low-income group and attracted other commuters from central city to relocate their house in suburban (Cervero and Tsai, 2003; Christopher et al., 1995; Martin, 2001; Sanchez, 2008). Nevertheless, a set of investigations notes that a “wise” location policy should not only consider where offices

are located but also must anticipate how reasonable the average travel distance and time is between work and home location when decentralization of employment is executed. Studies show that positive mobility impacts were more gained when the industrial location policy was implemented with consideration on balance of the home-to-work travel distance (Cervero, 1996; Cervero and Kockelman, 1997; Newman and Kenworthy, 1989; Giuliano, 1991; Dubin, 1991; Levinson and Kumar, 1994; Zhao et al, 2009). It is also important to concern that suburbanization of employment reduced travel time and distance, but on the other side, affected car dependency. According to Chatman (2003), commuters prefer not to use car when they live in dense mixed-use neighborhoods, in which enable them to walk, to use bicycle and to access public transport facilities. On contrary, living and working in less dense neighborhood influence commuters to use car.

The second group of studies reveals opposite findings that employment decentralization creates greater travel time and distance as well as the share of car use rather than their counterpart who commute to the city centre (Aguilera, 2005; Alpkokin et al., 2008; Giuliano and Small, 1993; Shearmur, 2006; Giuliano and Dargay, 2006; Marshall and Banister, 2000; García-Palomares, 2010). Locations in the suburban areas for certain cases have lesser well development with respect to road infrastructures, pedestrian and public transport systems compared to facilities found in the city centre. This then induces commuters to use private car, higher average daily distance traveled and travel time. Travis et al. (2010) demonstrate that urban sprawl and less compact and mixed zone in less central location create difficulties to non-motorized transport users because road alternatives are limited and the travel distance is quite far for home-to-work journeys making commuters have less mode choice to travel to the location. Commuters use car and this therefore has generated congestion during peak period, leading to increase of travel time and travel cost (Murphy, 2009).

A study by Yusak and Kitamura (2008) reports that employment location in the central city has added certain activities with different purposes (i.e. shopping, leisure trips) during commuting journeys with a very less amount of extra travel time and distance. However their counterparts who have office in the suburban areas need more efforts to engage in social activities during commuting journeys since changing route destinations, departure times, and chained trips are less flexible for them. Due to lack of social activities nearby their offices in the suburban area, they even must have stops to the city centre first for many cases as part of their work-to-home trips which then add total travel time and distance (Aguilera and Mignot, 2004; Thakuriah et al., 2006).

Another particular group of interest in the literature on the associations between location policy and commuters' travel behavior give some further clarification that external factors and policies besides the location policy seem to play important role on the effects on behavioral changes. For example Hassen (1995) analyses modal split due to location policy in Oslo and shows that the company decisions to allow free car parking and support subsidies to their employees to own private car strongly have created car dependency regardless where the offices were located. In addition, less concern on the improvement of public transport and non-motorized mode facilities attract the users split to use car. Other findings further confirm that socio-demographic variables such as income, perception of transport mode, commuting cost, and cultural and social characteristics of location are factors that determine commuters' travel

patterns (van Ommeren et al., 1999; van Wee, 2002; Ma and Banister, 2006; Parskher et al, 2008 Hjorthol, 2000; Sandow et. al., 2008, Maat and Timmermans, 2009).

The literature summarized so far that during the last decade, research on synthesis of commuting characteristics affected by location policy provided detailed results. One side concludes that positive results would be obtained if workplace is located in suburban area, but others counter those arguments, stating that the idea may be difficult to be implemented to deliver advantages of urban mobility because other external factors seem to influence changes in travels. Thus, we conclude that it is important to investigate an empirical analysis with regard to an evaluation on policy location in the Stavanger region, because although the case and the purpose of the study are quite similar between the present study case and other studies reviewed earlier, the geographical patterns and socio-demographics characteristics are unique for each location. This empirical analysis will enrich our knowledge with respect to relationship between location policy and travel behavior.

3. Study area background and dataset

Since the objective of the study is to examine the effects of location policy on commuters' travel patterns, data utilised in the study was based on a survey questionnaire to commuters who regularly travel to their office in suburban, semi urban and city centre of the Stavanger region¹. The survey was conducted by International Research Institute of Stavanger (IRIS) between autumn 2008 and spring 2009 as part of the *Bedrifts-RVU* projects which examined the impacts of the Forus area development on commuters' travel patterns in the Stavanger region. The data collection instruments are combination between an electronic and a paper-pencil survey, in which the respondents were asked to record their profile, current commuting travel characteristics (departure time, travel time, distance traveled and mode choice) and preferred mode of transport with reasons why they are likely to choose the mode. The questionnaire had 4 pages, consisted of 3 modules and 33 questions. On the first page, the respondents were informed the general aim of this study and followed by questions about profile of the respondents. The characteristics of travel they engage in that day was asked on the second page and preference on transport mode. Reasons to choose the preferred mode were questions asked on the last two pages. The questionnaire took between 15 and 20 min to answer. A total of 2,165 usable questionnaires were used in this paper, 74.32% from the suburban area, 5.36 % from the semi urban area and 20.32% from the city centre.

The survey was separately done in three different areas. The first data collection was conducted between September and October 2008 on respondents who their offices locate in the semi urban area lying in between the city centre and the suburban area of the Stavanger region. Employees of a research park in south-west of city centre consisted of two leading institutions in the Stavanger region: the University of Stavanger (UIS) and IRIS were the respondents of this survey. There are free parking spaces provided for bicyclist and auto users in many spots of this area. Public bus service is available with two routes running by around every an hour during working hour. 116 questionnaires were used in this study. The second data gathering was conducted between November and December 2008 on commuters who reside in the central Stavanger region. A total of 440 respondents working as the officer of Stavanger

¹ In this study, we define that the Stavanger region consists of Stavanger and Sandnes municipality.

municipality participated in the survey. Note should be made that this group has very good accessibility on public transport because the central bus and train stations resides very close to their offices and almost all major networks within the Stavanger region connects to the central station. Pedestrian and bicycle facilities including free bicycle parking park are widely available. There have quite limited free car parking lots provided by the firm, but paid car parking lots can be found in certain locations along the city centre. The last survey was conducted over respondents who commute to the Forus areas locating in the suburban area of the Stavanger region between February and April 2009. Employees of three firms [Statoil, National Oil Varco (NOV) and Kvadrat] were chosen and agreed to participate in the survey. The firms were selected because of the quantity of their employees commuting to the Forus area is large. Statoil and NOV are two big oil companies in Norway where their head office resides in the Forus area. Whiles Kvadrat is the biggest shopping mall in the Stavanger region. It should be noted that road infrastructures is well developed in the area in particular due to the presence of the national expressway (E39) linking to the Forus area. Seven bus routes serve the Forus area and the buses run with different frequency. The longest frequency is by around every 1 hour and the smallest frequency run by around every 15 min during weekday. In addition, all companies of this study provide free parking spaces for their employers as well as the visitors who use car, motorcycle and bicycle.



Figure 1. The Stavanger region

4. Methodologies

Using data from the commuting travel behavior survey, the relationship between location policy on commuting travels will be examined. Previous analyses were examined such issues by examining commuting travel patterns of one work-neighborhood who was affected a location policy, in which the company moved their office into the other part of the region. For example, Hanssen (1995) investigates changes in distance traveled, travel time, mode of transport for the work trip, and expressway payment on before and after the implementation of location policy for commuters in five companies in Oslo. Other approaches were conducted to examine commuters' travel pattern of a neighborhood designed by location policy (i.e. close to public transport stations or major road networks); and therefore compare its travel patterns with other groups who work in different environment where specific location policy was not implemented.

For this study, a comparison of commuters' travel characteristics residing offices in the suburban area (the Forus area), the semi urban area (the research park) and the city center of the Stavanger region will be first examined. In particular, we focus on the analyses of travel time, distance and the means of transport. The results are presented in Table 1 and 3. In addition, the study accounts commuters' preferred means of transport and reasons why they are likely to use the preferred modes. The results of this part can be found in figure 2a, 2b and Table 3.

Next, a set of regression analyses is conducted using commuters' distance travel and travel time as dependent variables and 21 variables were chosen for the explanatory variables based on previous studies and our assumptions on location policies in relation to travel patterns over commuters. A set of personal and mobility characteristics as well as spatial variables (home-based location) are selected to explain the individual's propensity to travel. The models also include mobility characteristics (car and bicycle ownership, driving license, and public transport discount facility). All the categorical explanatory variables are dummy coded and the results are presented in Table 5.

A binary logistic regression analysis was carried out to examine factors that most affect the propensity to car and bus use as well as cycling utilizing an iterative maximum likelihood procedure. In this part, we coded car use as 1 and did not use the mode as 0. The effects of the selected explanatory variables were tested and a positive sign means that the explanatory variables positively influence the probability of using the mode and a negative sign implies the opposite effect. The results are presented in Table 6 and discussed in the next section.

Table 1
Sample characteristics per workplace (n=2,165)

	The Forus area (suburban)		The research park (semi urban)		The city centre (urban)	
	n	%	n	%	n	%
Sample size	1609	74.32	116	5.36	440	20.32
Female	930	57.80	72	62.07	173	39.32
Male	679	42.20	44	37.93	267	60.68
Age						
18-25	104	6.46	1	0.86	7	1.59
25-40	578	35.92	41	35.34	84	19.09
40-65	919	57.12	71	61.21	343	77.95
65 +	5	0.31	3	2.59	6	1.36
Full time worker	1581	98.26	107	92.24	424	96.36
Part time worker	27	1.68	9	7.76	16	3.64
Has flexible working hour	1069	66.44	75	64.66	350	79.55
Has not flexible working hour	539	33.50	41	35.34	90	20.45
Driving license	1552	96.46	112	96.55	420	95.45
Has car	1496	92.98	103	88.79	394	89.55
Has bicycle	1289	80.11	99	85.34	362	82.27
Has bus discount card	1308	81.29	0	0.00	0	0.00
Stop during commuting journey for						
Dropping child	529	32.88	22	18.97	70	15.91
Dropping partner	266	16.53	22	18.97	105	23.86
Shopping	1160	72.09	68	58.62	296	67.27
Has short business trip during working hour	279	17.34	28	24.14	151	34.32
Means of transport for business trip during working hour						
Walking	31	2.37	3	2.59	141	0.32
Cycling	54	4.13	0	0.00	0	0.00
Bus	9	0.69	5	4.31	26	0.06
Car	32	2.45	83	71.55	160	0.36
Company car	3	0.23	1	0.86	50	0.11
Taxi	162	12.39	0	0.00	0	0.00
Home location						
Sandnes	421	26.17	14	12.07	40	9.09
Stavanger	880	54.69	81	69.83	338	76.82
Sola and Randaberg	165	10.25	12	10.34	39	8.86
Other	143	8.89	9	7.76	23	5.23

5. Descriptive statistics

Table 1 tabulates some key characteristics of the respondents. The sample size of commuter's work area in the suburban area is quite large (74.32%) compared with those from other areas. Female dominates more than 50% of total respondents for the suburban and the semi urban surveys. The age distribution shows that, two age groups (25-40 and 40-65) have quite large percentage in the sample. The sample is dominated

by full time worker. More than 50% of respondents further have flexibility in terms of the work schedule. Most of the respondents have car driving license (96.3%). The bus discount scheme provided by the local bus operator seems only to attract employees who work in the Forus area, since the survey shows that no respondents from the semi urban area and the city centre has taken this benefit. Shopping is the strongest reason why the respondents from the three areas have stop during commuting journey (more than 50%). Some respondents report further that they have short business trip during working hour and private car is the most used mode for this trip purpose. Finally, as shown in Table 1, more than 50% of the respondents live in the Stavanger municipality.

6. Travel time and distance

Table 3 tabulates mean travel time and distance by the three areas and modes. The average travel time for all trips by the suburban area commuters is 20.36 min. While the group of the semi urban commuters has 21.56 min to travel and the city centre group has the lowest mean travel time (19.3 min). With regard to travel distance, commuters who travel to the suburban area need 11.08 km for home-to-work journey, those who travel to the semi urban area take 10.75 km and those who commute to the city centre needs 7.54 km.

The mean travel time and distance for trips made by motorised transport is relatively stable regardless where people work. Trips made by bus and car have quite similar travel distance for the three areas. However the average travel time is very different between both modes, showing that bus has longer mean travel time. This may indicate how public transport still faces challenge to compete with car in the Stavanger region because travel time is very different between both modes. It should be noted that people walking and cycling to the city centre have the lowest mean travel time and distance than other groups. In contrast, bicycle users in the suburban area account for the longest mean travel time and distance than bicyclists from the other areas. For example, the suburban area bicyclists have travelled two times longer than bicyclists who work in the city centre.

Table 3

Mean travel time and distance by modal choice

	The Forus area (suburban)			The research park (semi urban)			The city centre (urban)		
	n	Time (minutes)	Distance (km)	N	Time (minutes)	Distance (km)	n	Time (minutes)	Distance (km)
Walking	95	14.24	3.12	4	27.5	5.38	79	13.58	1.75
Cycling	99	23.67	8.19	28	20.07	6.17	58	15.22	4.31
Bus	145	32.17	12.39	8	39.38	12.88	86	30.15	12.11
Car	1154	19.07	11.77	76	19.92	12.49	203	17.71	8.66
Other	116	20.65	11.62	0	0	0	14	24.93	9.24
Total	1609	20.36	11.08	116	21.56	10.75	440	19.3	7.54

7. Preferred means of transport

The commuters travelling to the Stavanger area were asked which modes they prefer to get to the work during summer and winter. In summer, car is the most favourable mode for commuters who work to the city centre as by 60.87% of the respondents choose it as their mode and only 9.66% of the respondents prefer bus. With respect to preferences on non-motorised modes, the survey accounts that 21.74 % of the respondents choose

bicycle and only 7.73% of the respondents prefer to walk. The commuters travelling to the semi urban area show quite similar results according to preferences on mode choice as car is the most chosen mode: 57.14% of car use, 6.43% of bus use, 32.14 of bicycle use and only 4.29% of walking. 35.68 % the respondents who commute to the city centre would like to use car for the commuting journey and 16.68% of those choose to use bus. The share of preferred mode choice by bicycle is by 27.81 % and 19.77% by walking. Quite similar results has also found on the preferences of mode choice. However the results show that the proportion of motorized transport is higher than the proportion of similar modes in the winter.

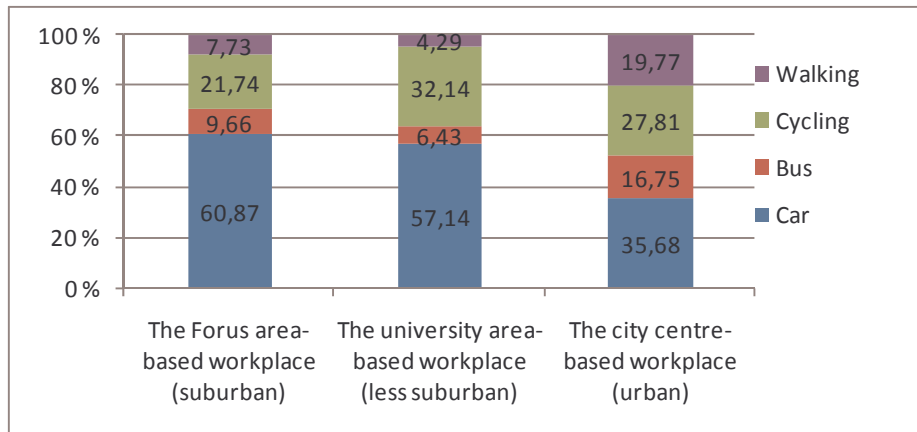


Fig. 2a. Percentage of preferred transport mode in summer by commuters per workplace

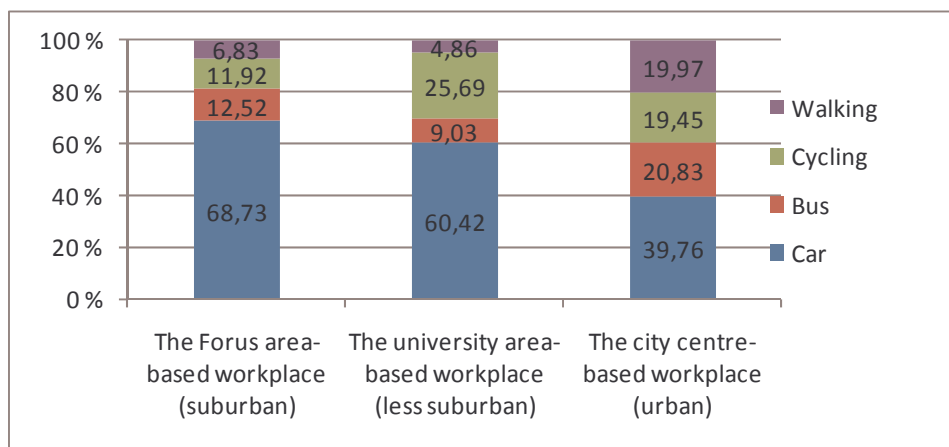


Fig. 2b. Percentage of preferred transport mode in winter by commuters per workplace

8. Perceptions using the preferred mode of transport

The respondents were asked to state their perceptions and motivations behind their choice of transport mode. A total of 12 statements were asked to respondents whether the statements are very important to influence their preference on the transport mode. Table 7 lists the statements for using their preferred transport mode by Stavanger commuter group with their perceptions. Only percentage of the respondents in each location group who answer for the statement is very important presented in this study. A breakdown by workplace in the suburban area reveals that 60.29% of total respondents in this group consider low travel time as their major concern to choose transport mode. They further choose means of transport which can allow them to have much flexibility

to obtain stops during commuting journey (42.03%). The means of transport can accommodate disabled person (38.38%) and the means of transport support business trip during working hour (28.55%). The other statements have less than 25% supports.

Commuters of the semi urban area note that low travel time is their highest concern (50%), They also believe that it is very important to consider transport mode that allow stops during commuting journey (39.47%). The means of transport supports business trips during commuting hour (33.33%)

With respect to perceptions across commuters who travel to the city centre, the study accounts that low travel time (48.15%) is the biggest reason to choose the preferred mode. Bus users prefer to use this mode because they believe it is an efficient mode (30.56%), Next, the means of transport should support business trip during commuting journey (29.63%) and the means of transport should allow stops during commuting journey (26.85%), 26.39% of the respondents in the city centre states that they prefer to use car because the cost is relatively cheap and 25.46% of the respondents state that the means of transport should allow physical activities.

Table 4

Perceptions to prefer transport modes by commuters in the three workplaces

	Rank	The Forus area (suburban)*	Rank	The research park (semi urban)*	Rank	The city centre (urban)*
I require low travel time	1	60.29	1	50.00	1	48.15
The means of transport may allow physical exercise	12	12.28	4	17.54	6	25.46
The means of transport may support sustainable environment	13	8.45	10	7.89	11	18.06
The means of transport may allow stops during commuting journey	2	42.03	2	39.47	4	26.85
The means of transport may support business trips during working hour	4	28.55	3	33.33	3	29.63
The means of transport may fit with the weather in Norway	11	14.75	9	7.89	10	18.75
The means of transport may accomodate disabled person	3	38.38	13	0.88	13	6.48
I prefer to use car because it is easy to park	7	21.39	5	13.16	12	14.58
I prefer to use car because the parking fee is relatively cheap	10	16.07	12	3.51	9	19.44
I prefer to use car because the operating cost is relatively cheap	8	18.39	11	6.14	8	19.44
I prefer to use bus because it is efficient	9	17.21	7	11.40	2	30.56
I prefer to use bus because the ticket is relatively cheap	5	23.91	8	8.77	5	26.39
I prefer to use bicycle because I can shower and change clothes in the office easily	6	21.82	6	11.40	7	21.76

* Percentage of number of the respondents per location who consider the statement is very important factor to prefer their transport mode.

9. Estimating commuters' travel demands

This section presents three models to estimate the commuting travel demand characteristics: (1) the travel distance, (2) the travel time and (3) the car use. Before the estimation results are presented, we first compare the different distance groups with

respect to means of transport, focussing on differences between workers who commute to the city centre and those who work to the suburban area of the Stavanger region. The results are shown in Figure 4a and 4b.

The travel distance can be divided into three groups: short trips (0-5 km), medium trips (5-10), long trips (10-15 km) and very long trips (15+ km). In the case of short trips, the results exhibit that quite high percentage of the respondents in the suburban area have used non-motorised modes during commuting journey by 40% of total mode use. In particular, the share of bicycle users in short trips involves 18% of total respondents and significantly reduces to be 7.1% with the group who travel 5-10 km. With respect to motorised transport the results show that car use has taken significantly role for commuters who travel to the suburban area as the percentage of car use increases as the travel distance increase. However the share of public transport is quite small for commuters.

The respondents in the city centre use car by only 33 % for short trips (0-5) km as they use bus (13.5%) cycling (18%) and walking (31.4%). High number of trips made by non-motorised transport can be influenced by many aspects, such as good pedestrian and bicycling facilities in the central of the Stavanger region. For medium trips, the share of walking reduces significantly, but the other groups of motorised mode increase their share in the city centre: car (66.7%) and bus (19.2%). We found that more percentage on bus use for the groups of commuter who travel for long and very long trips, while the share of car use is stable between two groups. This means that with respect to the trips made from 10 km, bus has important role as means of transport mode among commuters in the city centre.

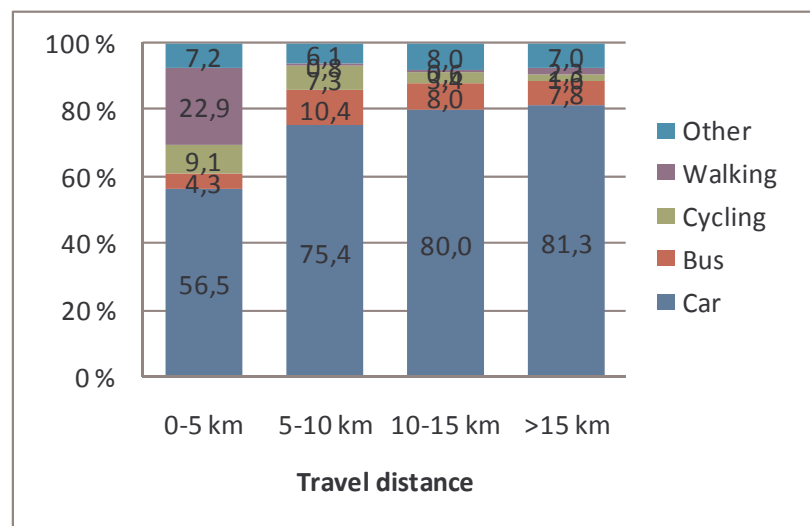


Figure 4a. Percentage of transport mode by different travel distance in the suburban area

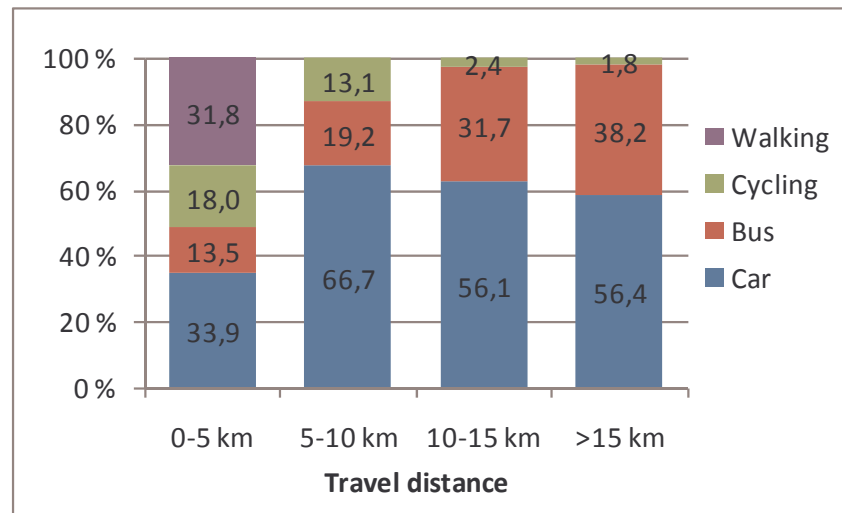


Figure 4b. Percentage of transport mode by different travel distance in the city centre

8.1. The models of travel time and distance

In order to examine the effect of the explanatory variables on the travel time and distance travelled among commuters in the Stavanger region, two regression analyses are estimated. The results indicate that the variable of workplace in the suburban area significantly influences reduction of travel distance and longer travel time. This confirms our earlier notion that decisions to locate work activity in the suburban area may lead to positive impacts on sustainable mobility as an indicator of good location policy. Commuters who travel to the city centre also tends to reduce travel distance and time as expected. This finding is obvious in the particular for European case where a city centre mainly consists of a mixed residential-commercial use, enabling commuters to travel with a short travel distance and time. The results further exhibit that the coefficient value of working in the suburban area variable is greater than the value of working in the city centre variable, clearly suggesting that although locating work activity in the suburban area has affected decrease of travel time and distance on commuters, the effects is not as much as reduction made by commuters who travel in the city centre. The results further indicate that the presence of bus discount card is positively related to the travel time and distance. This means that good bus marketing can encourage commuters to use bus. In terms of the effects of home location on the travel time and distance, the study has found that all variables have a significant effect at the 95% confidence level with a negative association. The lowest coefficient value is found in the variable of Sola and Randaberg residents and the highest one is found in the variable of Stavanger resident. These findings suggest that all home locations are likely to influence reduction of travel time and distance. However, the effects vary across location as those who live in the Stavanger region may have the highest reduction and those who live in Sola and Randaberg have the lowest reduction. In other words, being a Stavanger resident is found to result in a larger likelihood of having smaller travel time and distance rather than a Sola and Randaberg resident relates to similar travel purposes.

Being a commuter's bicyclist is found to have lower travel distance than commuters, with other modes. On the other hand, the use of bus and car increases travel time and distance. Younger commuters with age 25-40 are found to be less likely to have longer travel time and distance.

Table 5
Results of linear regression for commuters' travel distance and time

		Travel distance		Travel time	
		B ⁺	SE	B ⁺	SE
Constant		25.089***	1.339	42.205***	2.289
Workplace	Suburban area	-1.198*	0.655	-3.968***	1.119
	Semi urban area	Reference			
	City centre	-2.065***	0.602	-2.924***	1.028
Home location	Sandnes	-14.635***	0.498	13.326***	0.851
	Stavanger	-14.889***	0.464	-14.233***	0.793
	Sola-Randaberg	-13.953***	0.575	-13.459***	0.983
	Other area	Reference			
Sex	Man	-.130	0.254	1.056*	0.435
	Woman	Reference			
Age	18 – 25	-1.113*	0.637	-1.200	1.088
	25 – 39	Reference			
	40 – 64	-.699	0.643	-.341	1.098
	65 +	-.873	1.630	4.221	2.786
Permanent worker	Yes	0.543	0.804	-2.499*	1.374
	No	Reference			
Flexible working hours	Yes	0.416	0.270	-.348	0.461
	No	Reference			
Driving license	Yes	-.863	0.778	-1.140	1.330
	No	Reference			
Car ownership	Yes	0.566	0.571	-1.887*	0.976
	No	Reference			
Bicycle ownership	Yes	-.376	0.328	-.512	0.560
	No	Reference			
Bus discount card use	Yes	1.281**	0.426	3.283***	0.728
	No	Reference			
Direct bus route to workplace	Yes	-5.317***	0.386	-5.838***	0.660
	No	Reference			
Transport mode	Bicycle	-1.702***	0.296	-.103	0.507
	Bus	3.048***	0.385	10.620***	0.658
	Car	1.077**	0.342	-3.146***	0.584
	Other	Reference			
Stops during commuting journeys for private purposes	Yes	-.358	0.287	0.755	0.490
	No	Reference			
Stops during commuting journeys for business purposes	Yes	-.311	0.305	-.403	0.521
	No	Reference			
Number of observation	2165				
R	0.772				
R Square (Adjusted R Square)	0.596 (0.582)				
Std. Error of the estimate	15.404				
F	81.413				
Sign. (p-value)	< 0.001				

+Ustandardized coefficients, ***indicates significant at $p < 0.01$, ** $p < 0.05$ and * $p < 0.10$

8.2 The model of car use

The last mode is used to analyze factors that influence the propensity to use car. In this section a binary logistic regression approach is used to identify the factors that most affect propensity to use car across commuters in the Stavanger region. Some

explanatory variables discussed in the previous section are included in the models. The model further adds the explanatory variables which explain perceptions with respect to the mode they used.

Table 5 presents the estimation results of the binary logistic regression model, suggesting that commuters' who work to the suburban area tend to use car. On the other hand, those who work in the city centre has insignificant association with the propensity to use car. This result therefore confirms that, in the case of the development of the Forus area, the location policy to reside commercial activities in the area has statistically affected car use. With regard to socio-demographic factors, the finding exhibits that males are likely to use car. The groups of younger commuters (18-24) and older commuters (65+) were observed to be more likely to use car. We anticipated that the older the workers the more likely they use car because they have more financial ability to buy and maintain a car. However it is unexpected that younger commuters are also likely to use car. It appears that bicycle ownership has negative relation with the propensity to use car, indicating that workers who have bicycle seems to be likely to use this mode for working trips. Driving license availability has found to influence car use, as expected. The case whether no direct bus route affect the likelihood to use car is also analysed and the results show that both are positively related, indicating that those commuters who have no direct bus route for home-to-work journey increase the possibility to use car. Having stops during commuting journey for social (i.e. shopping, dropping off child and partner, and visiting friend) and business purposes has a positive association with the probability of using car. This finding is consistent with a set of studies conducted by Kitamura and Yusak (2006), arguing that more stops during commuting journey may lead to longer travel and probability to use car because car allows flexibility to workers to conduct several stops during commuting journeys. It should be noted further that a bigger coefficient value found for the variable of stops during commuting journey for social-related purposes rather than the value of the variable of stops during commuting journey for business trips has delivered a clear indication that social reason to engage in stops during commuting journeys has more strong effect on car use rather than business reason.

With respect to the variables of opinions on the means of transport, during summer season, commuters are less likely to use car. Car use was observed to be positively influenced by perceptions that commuters require low travel time, cheap operating cost of car and the cost of bus ticket is expensive. In addition, the estimation results indicate that those who consider sustainable modes are then less likely to use car.

Table 6
Results of binary logistics regression for commuters' car use

		B	S.E.	Wald	Exp(B)
Constant	Constant	-4.068***	1.032	15.536	.017
Workplace	City centre	0.815	0.449	3.294	2.258
	Semi urban	Reference			
	Suburban	1.983***	0.539	13.527	7.266
Home location	Sandnes	-0.050	0.415	0.014	0.952
	Stavanger	-0.438	0.403	1.180	0.645
	Sola and Randaberg	.332	0.483	0.471	1.393
	Other	Reference			
Sex	Man	0.578***	0.190	9.243	1.783
	Woman	Reference			
Age	18 – 24	0.943*	0.499	3.578	2.568
	25 – 39	Reference			
	40 - 64	0.784	0.495	2.511	2.191
	65 +	0.874***	0.228	14.679	2.396
Full time worker	Yes	-.398	0.618	0.416	0.672
	No	Reference			
Flexible working hours	Yes	0.002	0.184	0.000	1.002
	No	Reference			
Bicycle ownership	Yes	-.906***	0.302	9.006	0.404
	No	Reference			
Discount bus card	Yes	-.058	0.342	0.029	0.943
	No	Reference			
Driving license	Yes	2.211***	0.354	38.974	9.129
	No	Reference			
No direct bus route	Yes	0.873***	0.228	14.610	2.395
	No	Reference			
Stops during commuting journeys for social purposes	Yes	2.319***	0.270	73.693	10.164
	No	Reference			
Stops during commuting journey for business purposes	Yes	1.062***	0.396	7.188	2.893
	No	Reference			
Summer season	Yes	-.374*	0.206	3.302	0.688
	No	Reference			
I require low travel time	Yes	1.161***	0.271	18.401	3.192
	No	Reference			
I think operating cost of car is cheap	Yes	0.732***	0.178	17.008	2.080
	No	Reference			
I consider sustainable modes	Yes	-.384**	0.190	4.078	0.681
	No	Reference			
I think bus ticket cost is expensive	Yes	0.717***	0.183	15.300	2.048
	No	Reference			
Number of observation	2165				
-2 (L)	926.256				
R2	0.298				
PCP	0.434				

***Indicates significant at $p < 0.01$, ** $p < 0.05$ and * $p < 0.10$

5. Conclusions and discussion

The development of the Forus area which locates in the suburban area of the Stavanger region has been implemented by the local authority as a location policy to response growing economic activities in the Stavanger region and to improve the sustainability of urban mobility. This work is essentially an attempt to investigate the effects of such policy on the travel distance, the travel time and the share of transport mode.

A preliminary analysis that explored the mean travel time and distance has revealed that the mean travel time and distance for trips made by motorised transport is relatively stable regardless where people working. The results also show that commuters prefer to use car during summer and winter. However the proportion of car use is greater when the commercial location locates further from the city centre. With respect to opinions on the preferred mode of transport, the results have found that commuters concern mode of transport that can produce short travel time.

The results of the models further indicate that the location policy has significant impacts on the travel time and travel distance because people who work to the suburban area tends have longer travel time and distance rather than commuters who travel to the city centre. Being a commuter's bicyclist is found to have lower travel distance than commuters, with other modes. On the other hand, the use of bus and car increases travel time and distance. The results of the car use's model have revealed that the policy to locate commercial activities in the suburban area influences car use. With respect to the variables of opinions on the means of transport, the results show that perceptions of low travel time, cheap operating cost of car and cheap bus ticket as well as the sustainable modes are factors that influence probability to use car.

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