The impacts of telecommuting in Dublin

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Abstract

Telecommuting has been perceived as an effective means of reducing commuter related trips, travel time and emissions. Previously, the lack of access to broadband Internet connection and teleconferencing software from home has acted as a barrier to telecommuting regularly or at all. However, with advances in information and communication technology in recent years telecommuting is becoming a viable option for employers and employees to undertake.

This paper examines the current trends of full day and part day telecommuting in the Greater Dublin Area (GDA), and attempts to ascertain the most influential drivers and constraints related to telecommuting. The research presented estimates of the environmental benefits from individuals that telecommute. Finally, this paper seeks to determine the magnitude of carbon emissions savings from individuals adopting telecommuting and provides a social cost of carbon saving value.

The survey results presented suggest that approximately 44% of the population of the GDA telecommute at least once a month. The findings also indicate that needing contact with colleagues is the most influential constraint to telecommuting, while greater flexibility and avoiding travelling in peak periods are the most important drivers in the propensity to telecommute. Finally, this study shows that there are substantial carbon reductions and social cost of carbon savings. Thus illustrating how telecommuting can be a viable and sustainable policy in the GDA or in other similar sized regions.

1. Introduction

Telecommuting is essentially the elimination, or partial elimination, of a commute trip by working from home. Telecommuting has long since been seen as an effective way of reducing commuter-based emissions, travel times and congestion across the world. White et al (2007) details the scope of the benefits that could be realised from an increase in telecommuting such as; reduced travel time, spreading the demand on public transport services and higher productivity from employees. In the past the lack of access to high speed Internet connections, teleconferencing software, or the necessary equipment to fulfill their job from home has stopped people from telecommuting. With high-speed broadband, personal laptops/computers, tablets and smartphones becoming more affordable and easily accessible, telecommuting is becoming a viable option for some employers and employees. However, in Ireland telecommuting hasn't reached its full potential. Hynes (2014, 2013) puts this down to a lack of political and policy in this field to promote this sustainable method of working.

This paper examines the patterns of telecommuting in the GDA and will investigate via analysis of census and travel survey data, what are the current patterns of telecommuting in the GDA. This research includes a survey of employees to discover if they telecommute on a regular basis and to ascertain what are the drivers and constraints of telecommuting in the GDA. This paper will estimate the emissions savings from individuals that telecommute, and aim to prove that telecommuting is a sustainable, long-term solution to reducing congestion and emissions in the GDA. This paper does not delve into the complex social dimensions of teleworking or the costs associated with working from home (heating, lighting etc) rather examines the benefits of this sustainable transport option using existing data sources and a survey conducted for this research.

2. Literature Review

In Ireland, the largest source of information about telecommuting is gathered from the Census of Ireland, by the Central Statistics Office (CSO). The most recent census from 2011 gives a reasonable explanation of the current state of telecommuting in the GDA. According to the CSO, Dublin City contained a working population of 469,987 in 2011. Within that figure, 117,764 commuted from outside the area to work in Dublin City. These commuters make up 76% of all workers with a daily commute into Dublin. Due to the high percentage of commuters into the City, travel time is approximately 50 minutes (for a one way trip), which is almost twice the national average of 26.6 minutes. The CSO also stated that 83,326 persons, in Dublin, indicated that they worked mainly at or from home in 2011.

A drawback of relying on the data collected in the census is that some workers may indicate that they telecommute, yet they may only do so for part of the day, thus this will not give an in-depth description of the true figures of those who telecommute. Furthermore, there are some workers who operate home based businesses or independent contractors who should probably not be classed as telecommuters (Walls, 2004).

There have been many studies researching the drivers and constraints of telecommuting. They all have some similar discoveries, with many stating that land use patterns, internet infrastructure, socio-demographic characteristics, access to high speed internet, the presence of children at home, public transport access and cost of travel and fuel can serve to influence rates of telecommuting (Caulfield, 2015, Choo et al., 2005, Fu et al., 2012).

A widely discussed benefit of telecommuting is the reduction in travel time, cost, congestion and emissions. Though these have had varying levels of success depending on the country the research has been implemented. Nelson et al. (2007) ran a pilot telecommuting scheme across five US cities over two years and discovered that the emissions savings were relatively modest and the cost of continuing the research or carrying out further pilots was not worth the small emissions savings. Hynes (2013) finds that environmental concerns are one of the reasons, why people consider telecommuting. Choo et al. (2005) argues that more people choose to telecommute in opposition of fuel taxes and congestion charges, and that not only will telecommuting reduce the number of work related trips, but also non-work related trips for the commuter and their immediate family members.

The majority of people who telecommute tend to be higher and lower professionals. Also, these professionals tend to telecommute during traditional work hours (Alexander et al., 2010; Caulfield, 2015). These professionals telecommute for different reasons. Mokhtarian et al. (1998) state that women for example are more likely to telecommute for family reasons, personal benefits and reduced stress levels, while men were less likely to telecommute due to lack of professional interaction, household distractions, and they view themselves as lacking discipline. Although gender, family and personal benefits are not always the case in choosing to telecommute. Caulfield and Ahern (2014) state that a lack of an improved public transport infrastructure to compete with an increasing and expanding commuter population has led to some people having no alternative but to either buy a car(s) to travel to work or to telecommute. Handy and Mokhtarian (1996) state that the future of telecommuting is in the hands of employers to provide the opportunity and the employees to take the opportunity. Although this may not be applicable for all types of businesses or people.

3. Methods and Data

3.1 Census Data

The first dataset used in this study is derived from the 2011 census of Ireland. This particular dataset is known as Place of Work, School or College – Census of Anonymised Records, more commonly known as POWSCAR (CSO, 2011). The POWSCAR dataset contains data pertaining to the status of almost 2.8 million people, regarding whether or not they were in employment or education, and how they travelled to their place of work or education.

To further investigate what factors affect an individual's propensity to telecommute in the GDA, a number of other data sources were added to the POWSCAR dataset. This was required as the POWSCAR dataset does not contain information on many of the factors that some literature deemed significant in the uptake of telecommuting (White et al, 2007). These factors included deprivation and access to public transport.

Furthermore, individuals who were classed as agricultural workers or mobile workers were not examined in this study. This was due to the fact that the authors believed that these individuals could not alter the nature of their work or location(s) of work, and therefore would not be representative of the rest of the population of the GDA, and may skew results, such as travel times or travel distances. The first supplemental data added to the POWSCAR dataset was deprivation. This data uses an index developed by Haase and Pratschke (2012). This index measures affluence and deprivation of an area using a number of criteria, such as population change, age dependency ratio, lone parent ratio, education and unemployment rate. This study applied the index across the 690 electoral districts (this is one of the smallest resolution areas published in the Census) within the GDA. This study uses values ranging from -28 to 3 and over. The remaining set of supplemental data related to accessibility to public transport. The availability of bus and train are examined. The bus availability is measured in the number of stops per 1,000 people. Whilst the availability of train is set as yes or no, if the train is available in an area. These variables are explained in Table 1.

Table 1: Description of POWSCAR variables examined

Variable	
Deprivation score	
-28 to -8	= 1 if Deprivation score: -28 to -8
-7 to 0	= 2 if Deprivation score: -7 to 0
1 to 3	= 3 if Deprivation score: 1 to 3
Greater than 3	Reference category = Deprivation score Greater than 3
Bus stops per 1,000 people	
0-4 stops	= 1 if bus stops per 1,000 people: 0-4 stops
5-10 stops	= 2 if bus stops per 1,000 people: 5-10 stops
11-15 stops	= 3 if bus stops per 1,000 people: 11-15 stops
16 plus stops	Reference category = bus stops per 1,000 people: 16 plus stops
Rail availability	
Yes	= 1 if Rail availability: Yes
No	Reference category = Rail availability: No
Sex	
Male	= 1 if Sex: Male
Female	Reference category = Sex: Female
Marital status	
Single (Never married)	= 1 if Marital status: Single
Ever married	Reference category = Marital Status: Married
Age	
18-34	= 1 if Age: 18-34
35 and over	Reference category = Age: 35 and over
Household Structure	
Group 1: Single Person	= 1 if Household Structure: Group 1
Group 2: Lone parent: with at least one resident child aged 19 or under	= 2 if Household Structure: Group 2
Group 3: Lone parent: with resident children but none aged under 19	= 3 if Household Structure: Group 3
Group 4: Couple: with at least one resident child aged 19 or under	= 4 if Household Structure: Group 4
Group 5: Couple with resident children but none aged 19 or under	= 5 if Household Structure: Group 5
Group 6: Couple with no resident children	= 6 if Household Structure: Group 6
Group 7: Other Households	Reference category = Household Structure: Group 7
Residential Density	
Less than 2,000 people per sq km	= 1 if Residential density: Less than 2,000 people per sq km
2,001 to 50,000 people per sq km	= 2 if Residential density: 2,001 to 50,000 people per sq km
Over 50,000 people per sq km	Reference category = Residential density: Over 50,000 people per sq km
Car available	
One	= 1 if Car available: One

Two	= 2 if Car available: Two
Three	= 3 if Car available: Three
Four or more	= 4 if Car available: Four or more
No car	Reference category = Car available: No car
Industrial Group	
Group 1: Not stated	= 1 if Industrial Group: Group 1
Group 3: Manufacturing, mining and quarrying, Electricity, Gas, Water supply and Waste Management	= 3 if Industrial Group: Group 3
Group 4: Construction	= 4 if Industrial Group: Group 4
Group 5: Wholesale, Retail Trade, Transportation and Storage, Accommodation and Food Service Activities	= 5 if Industrial Group: Group 5
Group 6: Information and Communication, Financial, Real Estate, Professional, administration and support service activities	= 6 if Industrial Group: Group 6
Group 7: Public Administration and Defense; Compulsory Social Security	= 7 if Industrial Group: Group 7
Group 8: Education, Human Health and Social Work Activities	= 8 if Industrial Group: Group 8
Group 9: Other Service Activities	Reference category = Industrial Group: Group 9
Education level	
Secondary school	= 1 if Education: Secondary level
Third level	Reference category = Third level

3.2 Survey Data

To address some of the shortcomings of the Census data a survey was conducted. The purpose of the survey was to obtain extra information on those that aren't defined as telecommuters in the Census, namely those that don't telecommute five days a week and do so less frequently. The survey was distributed through email to a number of organisations in the GDA, with the instruction to forward the survey to colleagues and interested parties. To increase the impact of the survey and reach a wider demographic, the survey was also distributed across many social network platforms. The survey ran from January to March 2015. The survey had 230 responses. As the survey was an online survey, and is subject to the bias that brings, but the survey was aimed those working in organisations with access to email and this method was deemed to be the most appropriate to gather responses. Given the data collection method and the low sample number, one should keep these facts in mind when interpreting the results presented.

3.3 Modelling Approach

This section of the paper uses the data from the POWSCAR dataset and survey to model and determine what factors have an influence upon the propensity to telecommute in the GDA. To conduct statistical analysis of the POWSCAR and survey data, SPSS was used. The data from POWSCAR dataset and the survey was imported into SPSS, and the values were then defined in the software package for analysis.

As many of the variables to be examined had multiple outcomes, a multinomial logit regression model was used in this research to estimate these relationships. The models to be examined are done so on the basis of firstly, whether or not the individual telecommutes (POWSCAR data), and secondly, whether the individual telecommutes for a full day or part of the day, at least once a month or more often (survey data). The multinomial logit model takes the following functional form:

$$logit(p) = log\frac{p}{1-p} = \alpha + \beta I + \gamma H + e$$

Where;
p is the probability that the event of the dependent variable occurs (in this study it would be the probability that an individual telecommutes). *βI* is the set of individual specific characteristics (including age, gender, occupation, etc.). *γH* is the set of household specific characteristics. *e* is a random error term.

4. Results

4.1 Descriptive data

This section of the paper examines the comparison of demographics from the POWSCAR dataset of those who telecommute in the GDA and those who do not are shown in Table 2. The results show that a higher percentage of males (57%) telecommute compared to females. While individuals that are 35 and over telecommute more (83%). The results for the industrial groups show that those individuals in Industrial Group 6 are the highest percentage of individuals that telecommute (39%), while Industrial Group 5 were the second largest group of individuals that telecommute (17%) (These industrial groups are defined in Table 1). The education level suggests that those who have a secondary school education and a third level education have a similar percentage of individuals that telecommute. While couples with at least one resident child aged 19 or under at home were the largest demographic in household structure to telecommute.

Table 2: Demographics of those telecommuting in the GDA - POWSCAR

	Telecommute		Population		Difference
Variable	**N**	**%**	**N**	**%**	**%**
Gender					
Female	9,483	43	296,120	51	-8
Male	12,495	57	279,597	49	8
Total	21,978	100	575,717	100	
Age					
18-34	3,753	17	233,001	40	-23
35 and over	18,225	83	342,716	60	23
Total	21,978	100	575,717	100	
Industrial Group*					
Group 1	1,780	8	5,837	1	7
Group 3	1,853	8	53,144	9	-1
Group 4	1,167	5	13,703	2	3
Group 5	3,833	17	150,941	26	-9
Group 6	8,484	39	158,182	27	11
Group 7	422	2	42,078	7	-5
Group 8	2,544	12	125,544	22	-10
Group 9	1,895	9	26,288	5	4
Total	21,978	100	575,717	100	
Education Level					
Not stated	316	1	8,489	1	0
Secondary school	11,088	50	309,858	54	-3
Third level	10,574	48	257,370	45	3
Total	21,978	100	575,717	100	
Household structure*					
Group 1	2,049	9	53,264	9	0
Group 2	597	3	26,849	5	-2
Group 3	613	3	20,991	4	-1
Group 4	9,344	43	218,091	38	5
Group 5	2,735	12	61,971	11	2
Group 6	4,699	21	112,661	20	2
Group 7	1,941	9	81,890	14	-5
Total	21,978	100	575,717	100	

*Household structure and industrial groups are defined in Table 1.

The comparison of demographics from the survey dataset of those who telecommute in the GDA and those who do not are shown in Table 3. Examining the first variable, gender, 74% of males telecommute for a full day and part of the day. The next variable, age, the results suggest that the 18 to 34 age group have the highest percentage of individuals telecommuting. Which is not consistent with the POWSCAR data. This is the same for both full and part day telecommuting. Finally, the industrial groups with the highest percentage of individuals that telecommute for a full day are Industrial Group 1 and Group 6. While Industrial Group 1 and Group 4 have the highest percentage of individuals that telecommute for part of the day.

Table 3: Demographics of those telecommuting in the GDA - Survey

	Telecommuting				**Population**		**% Difference**	
	Full day		**Part day**					
Variable	N	%	N	%	N	%	Full day	Part day
Gender								
Male	64	74	61	74	132	66	8	8
Female	23	26	21	26	68	34	-8	-8
Total	87	100	82	100	200	100		
Age								
18-34	46	56	41	55	99	56	0	-2
34 and over	36	44	34	45	77	44	0	2
Total	82	100	75	100	176	100		
Industrial Group								
Group 1	52	60	45	55	100	50	10	5
Group 4	3	3	7	9	41	21	-17	-12
Group 5	0	0	0	0	3	2	-2	-2
Group 6	21	24	18	22	31	16	9	6
Group 7	6	7	8	10	17	9	-2	1
Group 8	3	3	2	2	4	2	1	0
Group 9	2	2	2	2	4	2	0	0
Total	87	100	82	100	200	100		

The survey that was conducted enabled the researchers to gain greater information on the drivers to telecommuting and also to try understand some of the perceived benefits of telecommuting. Table 4 shows 27% work from home at least once a week and 26% work from home for part of the day at least once a week. In the results from constraints to working from home, the survey the respondents were presented with the constraint and asked if it applied to them. The findings show that when the constraint of “the nature of the job doesn’t enable home working” is ignored, the largest reason for respondents indicating they couldn’t work from home is contact with other colleagues. The findings in Table 4 also show that few respondents indicated that a lack of space at home or inadequate IT facilities would act as a barrier to working from home. The final set of results in Table 4 show that 74% of respondents had a preference for working from home at least one day a week.

Table 4: Frequency and drivers to telecommute

Working from home frequency - full day	
Everyday	6%
Three or four times a week	5%
Twice a week	5%
Once a week	11%
Less often but at least one or twice a month	20%
Less often but at least once or twice a year	21%
Less than once a year or never	32%
Working from home frequency - part day	
Everyday	9%
Three or four times a week	6%
Twice a week	4%
Once a week	7%
Less often but at least one or twice a month	18%
Less often but at least once or twice a year	19%
Less than once a year or never	38%
Constraints to working from home	
Inadequate IT facilities	13%
Lack of space	5%
Prefer contact with colleagues	22%
Need contact with colleagues	29%
Don't have line manager's permission	21%
Line manager doesn't encourage it	16%
Prefer to work in the office	19%
Too many disruptions	14%
Already work at home as much as possible	10%
Nature of job does not enable home working	34%
To avoid additional energy costs	1%
Other	4%
Working from home frequency preference	
Everyday	11%
Three or four times more a week	15%
Twice a week	17%
Once a week	31%
Less often but at least one or twice a month	13%
Less often but at least once or twice a year	4%
Less than once a year or never	9%

Respondents were asked how they use the time they saved from not travelling to work. Respondents indicated that 29% would use the time for leisure, 27% said they would use it to work and the same amount said they would use it for household tasks. When respondents were asked how working from home impacted upon the number of hours worked per week. Interestingly, 57% said they worked more hours per week due to working from home and 34% said they worked the same amount. The results also show that there is a reduction in the number of trips and miles travelled by those that work from home. Finally, the results in Table 5 show that 77% indicated that working from home had a positive or very positive impact on quality of life.

Table 5: Benefits to working from home

How time saved use	
Work	27%
Leisure activities	29%
Shopping	2%
Childcare	10%
Other carer responsibilities	0%
Household tasks	27%
Community activities	2%
Other	4%
Effect on working hours per week	
Increases working hours by 1 - 2 hours	26%
Increases working hours by 3 - 5 hours	22%
Increases working hours by more than 5 hours	9%
Has no impact	34%
Reduces working hours by 1 - 2 hours	7%
Reduces working hours by 3 - 5 hours	1%
Reduces working hours by more than 5 hours	2%
Effect on car use	
No household car	18%
Increases number of trips	6%
Increases number of miles travelled	1%
Increases number of trips and miles travelled	1%
Increases number of trips but reduces miles travelled	0%
Has no impact	25%
Reduces number of trips	9%
Reduces number of miles travelled	15%
Reduces number of trips and miles travelled	27%
Reduces number of trips but increases miles travelled	0%
Benefit to quality of life	
Very positive impact	31%
Positive impact	46%
Has no impact	12%
Negative impact	4%
Very negative impact	0%
Not sure or other	6%

4.2 MNL Results

4.2.1 MNL Results using Census data

The results from the multinomial logistic regression model using the Census data are presented in Table 6. The deprivation index results suggest that individuals living in more affluent areas, i.e. areas with a high and positive score on the index, have a greater probability of telecommuting than those in lower scoring areas (with a coefficient of 0.493 compared to 0.260 and 0.128). Meaning individuals with a score of greater than 3, are 64% more likely to telecommute than those in an area with the lowest score. The impacts that public transport availability has on the choice to telecommute were examined in this study with two variables, one for bus availability and the other for rail availability. The results for the bus availability variable show that those with lower bus availability are more likely to work from home. The coefficient for rail was shown not to be significant, this indicates that rail availability does not provide an indication whether people are likely to telecommute.

The next set of variables examined are gender, marital status, household structure and age profiles. The results for gender show that, females are 9% more likely to telecommute compared to males. The results suggest that in regards to marital status, married individuals are more likely to telecommute than single individuals (coefficient of -0.332). Household structure is also examined; the results indicate that single people, couples with resident children but none under 19 and couples with no children were most likely to participate in telecommuting. This finding would suggest that having young children might act as a barrier to telecommuting full-time. This may be due to education or childcare needs of younger children. This is further explored in the results from the survey conducted. In relation to age profiles, the results of the multinomial logit model show, that individuals in the 35 and over age group are the most likely to telecommute (35% more likely).

Following on, residential densities were examined on their impact upon the uptake of telecommuting. The results suggest that individuals living in an area with lower residential densities have a higher likelihood of telecommuting (62% more likely). The results for the number of cars available at home show, that individuals with multiple cars available are more likely to telecommute than those with none. For example, those with four or more cars are 44% more likely to telecommute than those with no cars. The results also suggest, that the probability increases with the quantity of cars owned. The results for the social-economic groups show that, as one might expect, own account workers were the most likely to telecommuting. While higher and lower professionals were both also likely to telecommuting compared to all others gainfully occupied, (more likely by 24% and 73%, respectively). The results show for the industrial group that those working in Group 9, were the most likely to telecommuting, except for the individuals that did not state a response. With Group 7 being the least likely to telecommute (coefficient value of -1.932). Finally, the education variable shows that those with a higher level of education were more likely to telecommuting.

Table 6: Results of POWSCAR multinomial logit model

Variable	Telecommute	
	Coefficient	Standard Error
Deprivation Index		
Greater than 3	0.493*	0.026
1 to 3	0.260*	0.030
-7 to 0	0.128*	0.025
-28 to -8	0b	
Bus stops per 1,000		
0 to 4	0.127*	0.031
5 to 10	0.188*	0.025
11 to 15	-0.125*	0.026
16 plus	0b	
Rail available		
Yes	-0.006	0.018
No	0b	
Sex		
Female	0.083*	0.018
Male	0b	
Marital status		
Single (Never married)	-0.332*	0.025
Ever married	0b	
Age		
18-34	-1.043*	0.025
35 plus	0b	
Household structure		
Group 1: Single Person	0.003*	0.040
Group 2: Lone parent: with at least one resident child aged 19 or under	-0.315*	0.058
Group 3: Lone parent: with resident children but none aged under 19	-0.049	0.057
Group 4: Couple: with at least one resident child aged 19 or under	-0.168*	0.034
Group 5: Couple with resident children but none aged 19 or under	0.052	0.039
Group 6: Couple with no resident children	0.046	0.034
Group 7: Other Households	0b	
Residential Density		
Less than 2,000 people	0.485*	0.046
2,001 to 50,000 people	0.132*	0.022
Over 50,000 people	0b	
Car available		
One	0.134*	0.038
Two	0.130*	0.039
Three	0.217*	0.047
Four or more	0.362*	0.061
None	0b	
SEG		
Employers and managers	-0.366*	0.062
Higher professional	0.213*	0.064
Lower professional	0.546*	0.062
Non-manual	-0.971*	0.064
Manual skilled	-1.483*	0.087
Semi-skilled	-1.270*	0.077
Unskilled	-1.410*	0.103
Own account workers	2.403*	0.063
All others gainfully occupied and unknown	0b	
Industrial Group		
Group 1: Not stated	1.578*	0.052
Group 3: Manufacturing, mining and quarrying, Electricity, Gas, Water supply and Waste Management	-0.897*	0.042

Group 4: Construction	-0.107*	0.052
Group 5: Wholesale, Retail Trade, Transportation and Storage, Accommodation and Food Service Activities	-1.045*	0.036
Group 6: Information and Communication, Financial, Real Estate, Professional, administration and support service activities	-0.416*	0.033
Group 7: Public Administration and Defense; Compulsory Social Security	-1.932*	0.062
Group 8: Education, Human Health and Social Work Activities	-1.645*	0.039
Group 9: Other Service Activities	0b	
Education level		
Not Stated	-0.185**	0.078
Secondary school	0.003	0.020
Third level	0b	
N	575,717	
Nagelkerke R2	0.226	
Chi-squared	29860.409	
Degrees of freedom	39	
-2 log-likelihood	76869.855	

* Significant at 1%, ** Significant at 5%.

0_b values are set to equal zero because they are redundant.

4.2.1 MNL Results using survey data

Table 7 presents the results of two multinomial logistic regression models conducted on the survey data, which examined what demographic characteristics increased the likelihood of telecommuting at least once a month for a full day and for part of the day. Model 1 examines those that said they telecommute at least once a month for a full day and Model 2 examines those that telecommute at least once a week for part of the day. The results show that males are 64% more likely to telecommute for a full day, and far more likely (342%) to telecommute for part of the day than females. The next set of variables examined relates to the age profile, marital status and presence of children at home. The results for the age profiles show that individuals who were 34 and over are more likely to telecommute than those under 34, with the 18-34 age group having a coefficient of -1.226 and -0.783. The results show that those who are single are 48% more likely to telecommute for a full day and 206% more likely to telecommute for part of the day. While as expected, individuals with children at home are more likely to telecommute in both scenarios (coefficients of 0.664 and 0.449). This finding seems to contradict those found for household structure when examining the census data of full-time telecommuters in Table 6. Two things need to be taken into account here, firstly in the survey we didn't ask for the age of the children at home. So this may not be a contradiction it may be that the overall result shows that those telecommuting in the survey have children and they may be older. Secondly, it may show that while parents with younger children are unlikely to telecommute full-time as shown in Table 6, but are able to telecommute one day or two days a week. If this is the finding it is interesting and warrants further research.

The next variables relate to car ownership. The results show that individuals with three or more cars are more likely to telecommute than those who have one or two cars. Compared to those with two cars being the least likely to telecommute (coefficients of -1.708 and -0.558). While those who own petrol cars are 117% more likely to telecommute for a full day, while those with diesel cars are 75% more likely to telecommute part of the day. Finally, individuals who own bicycles are far less likely to telecommute full or part of the day, than those who do not own a bicycle (coefficients of -1.026 and -0.974).

Table 7: Results of survey data multinomial logit Model 1 and 2

Demographics	Model 1 Telecommuting at least once a month - full day		Model 2 Telecommuting at least once a month - part day	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Gender				
Male	.494	.612	1.487	.582
Female	0b		0b	
Age				
18-34	-1.226	.678	-.783	.642
34 and over	0b		0b	
Children at home				
Yes	.664	.699	.449	.637
No	0b		0b	
Marital status				
Single (never married)	.391	.738	1.120	.711
Ever married	0b		0b	
Car available				
One	-.056	1.268	-.312	1.268
Two	-1.708	1.247	-.558	1.250
Three or more	0b		0b	
Fuel type				
Petrol	.775	.489	-.287	.466
Diesel	0b		0b	
Bicycle available				
Yes	-1.026	.563	-.974	.525
No	0b		0b	
N	200		200	
Nagelkerke R2	0.266		0.182	
Chi-squared	20.484		13.549	
Degrees of freedom	8		8	
-2 log-likelihood	71.444		81.184	

4.3 Emission savings

This section of the paper examines the estimated emissions savings from the POWSCAR dataset. In order to estimate the values of emissions that could be saved by telecommuting, the emission values have to be calculated. As no travel distance is recorded in the POWSCAR dataset, the distance is calculated by multiplying the travel time by an average speed per mode. It should be noted that this is just a proxy for speed and is the best possible estimate to calculate the distance travelled from the POWSCAR data. Furthermore, to calculate the kgCO2 per kilometre travelled, the distance was multiplied by the different values given to each mode of transport, (such as 0.005 kgCO2 for cycling or 0.17 kgCO2 for a driver alone in a private car). Since, the POWSCAR records only contain the travel time per trip, for the kgCO2 per day, the kgCO2 per km would need to be multiplied by 2 (Walsh et al 2008; NRA, 2011). Then the kgCO2 per day would be multiplied by 215 (average working days per year).

As the survey results suggest that approximately 44% of the population of the GDA telecommute at least once a month (based upon the survey data), and the majority of respondents would like to telecommute at least once a week is it reasonable to suggest to test the following scenarios at 20% and 50% of the population telecommuting one day or two days a week.

Table 8: POWSCAR Emissions savings per year – Industrial Group

Industrial Group	kgCO2 saved: 1 day telecommuting		kgCO2 saved: 2 days telecommuting	
	20% Pop	50% Pop	20% Pop	50% Pop
Group 3	3,449,138	8,622,844	6,898,276	17,245,689
Group 4	1,090,868	2,727,170	2,181,736	5,454,339
Group 5	7,514,416	18,786,040	15,028,832	37,572,080
Group 6	8,243,184	20,607,960	16,486,368	41,215,921
Group 7	2,709,560	6,773,899	5,419,119	13,547,799
Group 8	6,937,411	17,343,528	13,874,822	34,687,056
Group 9	1,228,123	3,070,306	2,456,245	6,140,613
Total	31,172,699	77,931,748	62,345,398	155,863,496

This section of the paper contains the estimation of the social cost of carbon (SCC) savings from the POWSCAR dataset. According to the UK Government Economic Services (GES, 2002), "the social cost of carbon is usually estimated as the net present value of climate change impacts over the next 100 years (or longer) of one additional tonne of carbon emitted to the atmosphere today. It is the marginal global damage costs of carbon emissions."

The SCC is used to estimate the economic cost of CO2 emissions. This calculation is also used to evaluate the cost of activities that produce CO2 emissions, in this case commuting to the place of work. The value of SCC savings is important, this is because the value can be used as a metric to influence policy changes. SCC is also important because it can give an actual monetary value to the amount of CO2 produced, i.e. a value on the amount of CO2 saved by individuals switching from commuting to telecommuting in the GDA.

In order to estimate the total value of SCC savings that could be saved by telecommuting, the SCC value per tonne of CO2 produced is multiplied by the number of tonnes of CO2 produced per mode and per industrial group. The value of SCC is €39 per ton of CO2 (Dof, 2009).

Table 9: POWSCAR Social cost of carbon saved per year – Mode of Transport

Mode of Transport	Social saving of CO2: 1 day telecommuting		Social saving of CO2: 2 days telecommuting	
	20% Pop	50% Pop	20% Pop	50% Pop
Walk	€194	€305	€388	€611
Cycle	€785	€1,235	€1,570	€2,469
Bus	€10,000	€15,726	€20,000	€31,451
Rail	€54,092	€85,065	€108,185	€170,129
Motorcycle	€16,310	€25,649	€32,620	€51,297
Drive Alone	€1,713,239	€2,694,207	€3,426,478	€5,388,414
Drive Passenger	€63,605	€100,023	€127,209	€200,047
Van	€1,858,225	€2,922,209	€3,716,450	€5,844,418
Total	€3,716,450	€5,844,418	€7,432,901	€11,688,836

5. Conclusions

This study found that 44% of the population, in the survey sample, of the GDA telecommutes at least once per month. Comparing that figure to the 3% telecommuting, reported from the census data, there is a substantial difference. The authors believe this is due to the limitations of how the census asks questions. With the respondent only allowed to pick one option in the census, and not having the space to explain in more detail their working arrangements. With the ever-increasing amount of information and communication technology, that is making telecommuting more possible and easier than previously.

The findings of this research show that those that partook in telecommuting reported it had a positive impact on quality of life and reduced the number of trips and distances traveled. The majority of barriers in relation to not being able to telecommute were essentially their job or manager didn't allow it to happen. From a productivity point of view it is interesting to note the majority of respondents said they used the time they saved commuting to work more.

Many of the results produced from the Census analysis provide intuitive findings. The results for the availability of rail is not significant in determining if telecommuting is more likely, while the variable on bus availability was shown to have an influence. This may be due to the fact that bus is the largest mode of public transport in the GDA and rail would have a much smaller mode share, however it is a finding that requires further investigation. Similarly, the findings on household structure and the number of children in a household provide an interesting insight. As highlighted in the discussion of the results this may be suggesting that those with younger children are less likely to be able to telecommute on a fulltime basis.

The results how majority of the GDA would like to telecommute one day a week. If this were the case, there would be a significant carbon saving. If 20% of the population of the GDA telecommuted one day a week for a year, that would result in a saving of almost 60,000 tonnes of carbon. This demonstrates the potential of this sustainable transport mode to reduce carbon emissions.

While policy documents such as Ireland's national Smarter Travel plan (DoT, 2009) outline methods of encouraging and supporting telecommuting as a means of reducing emissions, via the provision of better internet connections and public sector targets, it is not yet clear what impact such measures have had. As it becomes increasingly likely that Ireland will miss its current emissions reductions targets (Taisce, 2015), and with the transport sector being a major source of greenhouse gases, there is need to understand how better utilize and promote non-traditional solutions such as telecommuting.

As telecommuting is an evolving behavior, there is need for more research to be undertaken to examine what role recent improvements in mobile internet and devices are playing for this sector. There is also a need to examine how policy can be best constructed to overcome the cultural and work place barriers to increased telecommuting.

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