Australasian Transport Research Forum 2011 Proceedings
28 - 30 September 2011, Adelaide, Australia
Publication website: http://www.patrec.org/atrf.aspx

An empirical assessment of teleworking using the Sydney Household Travel Survey data

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Abstract

Teleworking has long been considered an important demand-management strategy that can assist in easing congestion problems and associated environmental impacts. Recent advances in Information and Communications Technology (ICT) has reinforced its appeal as a cost-effective solution.

Teleworking could be a viable demand management strategy in Sydney where pressures on the network, and the growth in demand, are focussed on the peak periods. Given that journey to work trips comprise 27% of all trips during the morning peak, teleworking provides a relatively easy and low-cost option for reducing these trips during this period.

To inform the discussion and policy in Sydney, this paper analysed the Sydney Household Travel Survey data to assess the impacts of teleworking on travel demand and how application may be targeted to maximise benefits.

The analysis showed that:

- the incidence of teleworking in Sydney was small but growing;
- teleworkers were more likely to be: males; aged 31 to 50 years; those in couple with children households; those in the highest income bracket; managers, professionals and administrators; and those employed in the property and business services industries;
- workers who worked from home made less trips overall, travelled less distance and generated less VKT than those that went to work; and,
- when considering expanded application, the following types of workers were likely to generate more transport benefits: those with fixed hour work schedules; those working in non-centres; those with longer home-to-work distances, especially those who travel by private vehicle.

1. Introduction

The Australian Telework Advisory Committee (ATAC) report to the Australian Government provides a comprehensive list of advantages associated with teleworking. The range of benefits is at various levels. From the Government's perspective, teleworking can facilitate the revitalisation of rural and regional areas, increase work participation among people with disabilities, assist in ensuring continuity of services during disaster management and contribute to overall gains at the macroeconomic level. From a business standpoint, teleworking may increase productivity, help to alleviate skill shortages and address issues with regards to an ageing workforce. From an employee's point of view, it can be a useful arrangement that saves travel time and provides flexibility to reconcile work and family demands (DCITA and DEWR 2006).

In relation to transport, teleworking has long been considered an important demand-management strategy that can assist in easing congestion problems and associated

environmental impacts (DCITA and DEWR 2006). Reducing peak pressures through demand management strategies such as teleworking are cost-effective ways of maximising network capacity (Twiney and Rudd 2005).

In terms of environmental benefits, Telstra (2008) estimated that teleworking could save about 242 kg of carbon emissions per employee per year, from the reduced travel and work related energy efficiencies. Assuming an uptake of 5%, this was estimated to translate to a reduction of one million tonnes in annual greenhouse gas emissions. With recent advances in Information and Communications Technology (ICT) making teleworking even cheaper, easier and more effective; the advantages of the arrangement are reinforced. These benefits were placed in the forefront of discussion through the recent release of the National Broadband Network Blueprint which set a target of one in eight Australians (or 12%) able to work from home by 2020. An increase in the number of people working from home for half of their week was estimated to reduce peak hour demand by 5% which alone can save 120 million litres of fuel and 320,000 tonnes of carbon in a year (Hudson 2011).

Teleworking could be a viable solution in Sydney where the demand on the network is not only concentrated in the peak periods, but also, when the *growth* in demand is highest (Corpuz 2006). Given that journey to work trips comprise 27% of all trips during the morning peak (TDC 2010), teleworking provides a relatively easy and low-cost option for managing these trips during this period.

To inform the discussion and policy in Sydney, it would be beneficial to assess the efficacy of teleworking using empirical information. The focus of this paper is on the transport impacts, specifically how teleworking affects travel demand and how application may be targeted to maximise benefits.

In particular, this paper analysed the Sydney Household Travel Survey data to:

- examine the prevalence and uptake of teleworking;
- quantify and describe workers with teleworking arrangements in Sydney;
- compare work arrangements, home to work distances and travel patterns of those with and without teleworking arrangements; and
- assess differences in trip-making and VKT between those who did and did not telework.

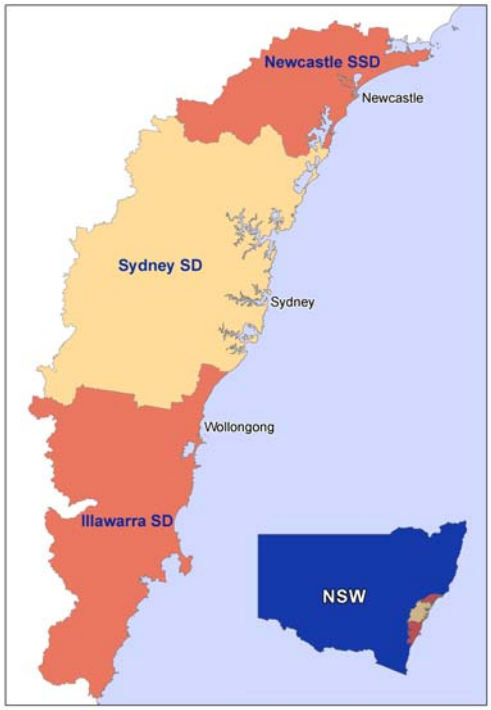
2. About the Household Travel Survey

Data from the Sydney Household Travel Survey (HTS) were used in the analysis in this paper. The HTS is the largest and most comprehensive source of personal travel data for the Sydney Greater Metropolitan Area (GMA). This area includes the Sydney and Illawarra Statistical Divisions and the Newcastle Sub-Statistical Division (Figure 1).

The HTS is the longest running household travel survey in Australia, having been running continuously since 1997. Detailed trip information for each day of the year, as well as socio-demographic information, is collected by face-to-face interview. For further details about the HTS, its scope, coverage and methodology, see TDC (2010).

The analyses presented in this paper were largely based on the 2009/10 estimates which were derived from five years of pooled data collected from June 2005 to June 2010 weighted to the 30 June 2009 population. The total sample for this time period consisted of 15,880 households; 40,886 individual respondents; 148,902 linked trips and; 174,156 unlinked trips. The 2001/2002 and 2005/06 HTS estimates from five year-pooled datasets were used along with the 2009/2010 data for the time series analysis.

Figure 2.1 Sydney Greater Metropolitan Area (GMA)



3. Definition of teleworking

This section focuses on defining teleworking, as collected in the HTS and as used in the analysis in this paper. Some discussion is also provided about issues with regards to the HTS questions that may affect interpretation and comparison with other data on teleworking.

In the HTS, there are two main questions on teleworking. Workers with or without a fixed place of work, excluding those who work from home, were asked,

Q24 Do you work at home on some days as part of your employer's teleworking policy?'

Workers who were away from their usual fixed job address on their travel day were then asked the following question:

Q63 Would you describe your Travel Day as…?
A day on which you do not usually work
A normal working day at another workplace
A teleworking day
Or were you away from work for some other reason

Data from these questions for employed persons aged 15 years and above were analysed along with their socio-demographic and trip characteristics for this paper. For Q24, the scope was narrowed to those with a fixed job address to make the analysis consistent with Q63. Therefore, for the purposes of this paper, we would define a teleworker as follows:

An employed person aged 15 years and over, residing in the Greater Metropolitan Area of Sydney, who worked in a fixed job address, who also indicated that they worked at home on some days as part of their employer's teleworking policy.

The term teleworker will be used interchangeably with the term telecommuter. Additionally, a teleworker would be considered as having 'teleworked' or 'worked from home' if they identified their travel day in Q63 as a teleworking day.

It should be noted that the HTS question referred to teleworking from home only, although teleworking can refer to working from home or other location other than the worker's usual job location (Collantes and Mokhtarian 2003, Roads and Traffic Authority 2009). This approach of focusing on home-based teleworking was also taken by Choo et al (2005) because of the relatively smaller incidence of centre-based teleworking. In most respects, the HTS approach was similar to that of the Australian Bureau of Statistics (ABS) which defined teleworkers as 'employed persons aged 15 years and over in New South Wales who worked at a fixed workplace, for a business that was not based at their own home and in the last 3 months worked at home during normal business hours for a full or part day' (ABS 2001).

There were, however, two key differences between the HTS and ABS definitions. Q24 in the HTS used the words '*as part of your employer's teleworking policy'* which suggested a formal and/or regular arrangement whereas the ABS defined a teleworker as one who worked at home in the last 3 months. The ABS was also clearer about working from home during normal business hours, which excluded workers who do more work at home outside normal office hours. It is also worth stating that the HTS wording contained some level of ambiguity with regards to the time frame of the teleworking activity. It has been recognised that the question may be improved by specifying a period, eg 'in the last three months', such as the approach taken by Australian Bureau of Statistics. These definitional differences resulted in disparities in the reported incidence of teleworking from these two sources as will be seen in the next section.

Other studies took an even more explicit approach in their definitions. In a study that used data on State of California workers, four mutually exclusive groups (current telecommuter, after telecommuter, before or after telecommuter and ever telecommuter) were defined based on the currency, period and frequency of their telecommuting (Ory and Mokhtarian 2005, Collantes and Mokhtarian 2003).[1]

As can be seen, there could be many sources of definitional differences and ambiguities, a problem discussed in the paper by Mokhtarian and others (2005). This lack of consistency in the definition of teleworking has made it difficult to establish the definitive level of uptake of the arrangement in Australia (DCITA and DEWR 2006). These definitional issues should be considered closely for any future surveys dedicated to teleworking.

4. Access and use of teleworking arrangements

Teleworkers did not comprise a substantial proportion of workers but the incidence has been steadily growing in the last decade. Based on the Household Travel Survey, 3.8% (72,000) of workers in Sydney, whose usual job is not from home but from a fixed job address, indicated that they worked at home on some days as part of their employer's teleworking policy in 2001. This figure grew to 5.8% (120,000) in 2005 and further on to 7.5% (172,000) 2009 (Figure 4.1).

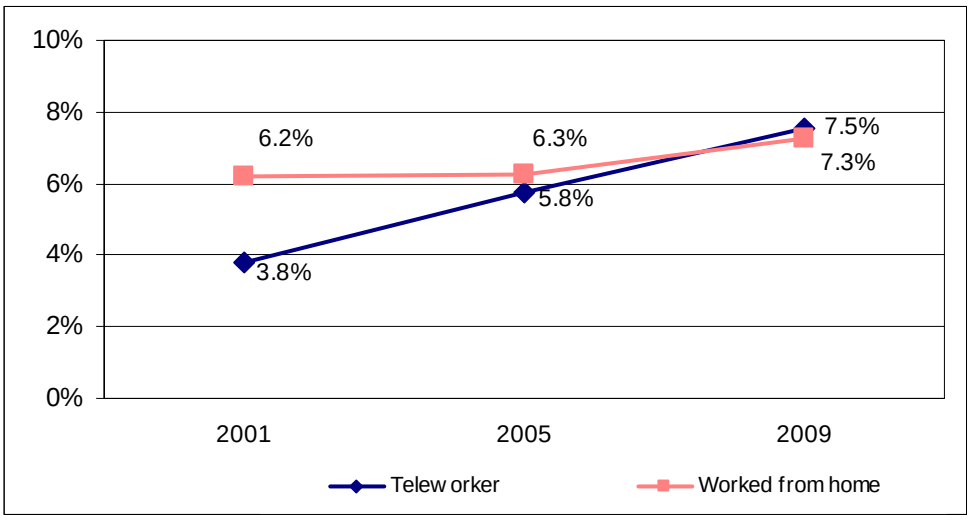
In comparison, the ABS (2001) reported that there were 8.6% of teleworkers in Sydney (6.9% for balance of New South Wales). These estimates are different from the HTS result

[1] In the teleworking studies cited here, teleworkers were defined to exclude home-based and self-employed people who normally worked from home rather than in an office. This study used this same approach in order to properly assess the impacts on travel.

due to definitional differences that were explained in the previous section. Suffice to say that both sources indicated that the proportion of teleworkers in Sydney was small[2].

The uptake of the arrangement by teleworkers has not been remarkable. The HTS shows only 6.2% (2,500) of those with access to the arrangement availed of it on an average day in 2001, compared to 7.3% (7,000) in 2009.[3]

Figure 4.1 Per cent of workers with access to teleworking and those who availed of it on an average day



5. Characteristics of teleworkers

Teleworkers were more likely to have certain socio-demographic and employment characteristics (Table 5.1). Broadly, teleworkers were more likely to be: males (59%); aged 31 to 50 years (68%); those in households with two vehicles (47%); those in couple with children households (58%); those in the highest income bracket, ie equal to and above $60,000 (67%); managers, professionals and administrators (84%); and those employed in the property and business services industries (27%).

These HTS findings were aligned with the results from other large collections in California, Finland and the United Kingdom. Dam et al (2009) reported that telecommuters were 'highly educated, had high incomes (higher than average), were middle-aged, and were male professionals'.

The higher incidence shown in the HTS of teleworkers among those in households with children was also consistent with observations cited by Golden (2008) that teleworking was used as a coping mechanism to manage work and family demands especially during emergencies. This author indicated that 'particularly among fathers', working at home was used to improve work and family balance, a result which was also consistent with the higher proportion of males among teleworkers in the HTS. The same finding was reported by the ABS (2005) with 10.8% of male workers using teleworking to care for family compared to 7.8% of female workers who tended to use other work arrangements more than teleworking.

[2] The ATAC report suggested a much higher incidence but this is because home-based and self-employed workers who do not necessarily have a fixed job location outside the home were included (DCITA and DEWR 2006).

[3] Proportion of uptake is based only on teleworkers with a fixed job location who worked on their travel day.

Table 5.1 Workers who have access to teleworking by socio-demographic and employment characteristics, 2009

		Teleworkers	Per Cent	All Workers	Percent
SEX	Male	101,000	59%	1,108,000	48%
	Female	71,000	41%	1,184,000	52%
		172,000	*100%*	*2,292,000*	*100%*
AGE	15-20	1,000	0%	211,000	9%
	21-30	19,000	11%	455,000	20%
	31-40	58,000	34%	547,000	24%
	41-50	59,000	34%	558,000	24%
	51-60	28,000	16%	376,000	16%
	61-70	7,000	4%	116,000	5%
	Over 70	1,000	1%	30,000	1%
		172,000	*100%*	*2,292,000*	*100%*
NUMBER OF VEHICLES IN HOUSEHOLD	None	4,000	3%	120,000	5%
	One vehicle	52,000	30%	673,000	29%
	Two vehicles	81,000	47%	958,000	42%
	Three or more	35,000	20%	541,000	24%
	Not stated	0	0%	0	0%
		172,000	*100%*	*2,292,000*	*100%*
HOUSEHOLD TYPE	Lone person	15,000	9%	212,000	9%
	Couple only	37,000	22%	471,000	21%
	Couple with children	100,000	58%	1,201,000	52%
	One parent with children	9,000	5%	224,000	10%
	Other	10,000	6%	184,000	8%
		172,000	*100%*	*2,292,000*	*100%*
INCOME OF WORKER	<$10,000	5,000	3%	214,000	9%
	$10,000 to less than $20,000	5,000	3%	247,000	11%
	$20,000 to less than $35,000	11,000	6%	457,000	20%
	$35,000 to less than $60,000	37,000	21%	683,000	30%
	$60,000 +	115,000	67%	692,000	30%
		172,000	*100%*	*2,292,000*	*100%*
OCCUPATION	Managers, professionals and administrators	146,000	84%	1,016,000	44%
	Technicians, trades and related workers	4,000	2%	204,000	9%
	Community, service, sales and clerical workers	23,000	13%	839,000	37%
	Machinery operators and drivers	0	0%	76,000	3%
	Labourers	0	0%	156,000	7%
	Not stated or inadequately described	0	0%	0	0%
		172,000	*100%*	*2,292,000*	*100%*
INDUSTRY	Agriculture, Forestry and Fishing	1,000	0%	13,000	1%
	Mining	1,000	1%	15,000	1%
	Manufacturing	16,000	9%	241,000	11%
	Electricity, Gas and Water Supply	2,000	1%	20,000	1%
	Construction	4,000	2%	42,000	2%
	Wholesale Trade	7,000	4%	74,000	3%
	Retail Trade	9,000	5%	306,000	13%
	Accommodation, Cafes and Restaurants	3,000	2%	158,000	7%
	Transport and Storage	4,000	3%	86,000	4%
	Communication Services	11,000	7%	64,000	3%
	Finance and Insurance	21,000	12%	159,000	7%
	Property & Business Services	47,000	27%	300,000	13%

	Teleworkers	Per Cent	All Workers	Percent
Government Administration and Defence	9,000	5%	137,000	6%
Education	20,000	11%	235,000	10%
Health and Community Services	9,000	5%	263,000	11%
Cultural and Recreational Services	2,000	1%	60,000	3%
Personal and Other Services	7,000	4%	118,000	5%
Not stated, inadequately described, non-classifiable	0	0%	1,000	0%
	172,000	*100%*	*2,292,000*	*100%*

Note: Estimates are rounded to the nearest thousands but cited percentages are based on actual numbers.

6. Teleworking, trip-making and distance travelled

One of the key questions that is asked when assessing the efficacy of teleworking is whether it reduces distance travelled, and especially vehicle kilometres travelled (VKT). In this section, we examine this issue. Firstly, it is interesting to note that teleworkers were generally more mobile than non-teleworkers. They made more trips overall, more car trips, travelled longer distances on average and generated more VKT than non-teleworkers. These differences were all statistically significant (Table 6.1).

However, when teleworkers *actually worked from home*, they made fewer trips (including car trips) and travelled shorter distances (including VKT) on average than those teleworkers who went to work. These differences were statistically significant for trip, distance travelled and VKT per person. The difference in car trips per capita was borderline significant (Table 6.2).

While it seems intuitively obvious that workers who worked from home should make less trips than those who went to work, this result needed to be tested because of the possibility that those who worked at home may, instead of their trip to work, generate other trips resulting in the same number or potentially more trips, some of which may even be more unsustainable in nature. The result shown by the HTS that teleworkers generated less trips and distance travelled when they worked from home is favourable for demand management objectives.

It is important to clarify though that this comparison was made between two different mutually-exclusive groups of teleworkers, between those who worked from home and those who worked at the usual job location. Ideally, the comparison should be made for the same group of teleworkers, looking at their trip-making on a day they teleworked versus a day they went to work, to clearly assess the trip reduction effect of teleworking. Except for the purpose of quantifying the direct trip reducing effect which should be done using the latter approach, the method applied here, nevertheless, is informative and provides clear indications of how working from home was associated with less trips on average than when commuting to a fixed place of work.

These HTS findings were consistent with other studies. Zhou et al (2009) citing other works stated that most researchers agree that teleworking reduces trips. Choo et al (2002) in their multivariate analysis of the impacts of telecommuting on VMT (vehicle miles travelled) per capita, found it had a small VMT reducing effect but was only significant at 90% confidence interval. This study measured the impacts at the aggregate VMT per person level and the researchers suggested that the effect was marginal due mainly to the small incidence of telecommuting.

Table 6.1 Average number of trips[4] and distance travelled by whether teleworker, 2009

	Teleworker (n=1530)[5]	Non-Teleworker (n=18943) [6]	P value [6]
Trips per person	5.15	4.80	0.000
Car trips per person	3.36	3.13	0.002
Distance travelled per person (kms)	42.02	38.50	0.001
VKT (vehicle kms travelled) per person	29.28	25.39	0.000

Table 6.2 Average number of trips[5] and distance travelled of teleworkers by whether worked from home, 2009

	Teleworkers, Worked from home (n=51) [6]	Teleworkers, Went to work (n=651) [6]	P value
Trips per person	4.26	6.26	0.000
Car trips per person	2.86	3.50	0.083
Distance travelled per person (kms)	25.56	51.37	0.000
VKT (vehicle kms travelled) per person	19.83	34.48	0.000

Note: The averages indicate average trip-making in a day. Teleworkers who did not go to work for some other reason other than to telework, including being away from work because it is 'a day on which the worker did not normally work' were excluded.

7. Maximising benefits by targetting teleworking

In the previous section, it was demonstrated that teleworking days are associated with fewer trips and shorter distance travelled per capita. To fully take advantage of these impacts, it will be informative to empirically assess areas which can be targeted to maximise the potential gains. Here, we analyse teleworkers in relation to their:

- work schedule
- job location: whether in the CBD, in other centres or in non-centres; and,
- home to work distance
- usual mode of travel to work

7.1 Teleworking by work schedule

In the Sydney GMA, there were 2.3 million workers with a fixed main job location in 2009 (Table 7.1). Workers with fixed hours of work (same each day), comprised the highest proportion (931,000, 41%) in 2009. Among these workers though, only 4% are teleworkers.

Fixed time workers exert considerable pressure during the peak due to their number and the nature of their start and finish times. Close to half (46%) of fixed-time workers were required to start work during the highest demand period between 8.01am-9am. A considerable proportion (23%) were required to start in the pre-peak shoulder (7.01am-8am) while a small percentage (5%) were required to start in the post-peak shoulder (9.01am-10am) (Shaz K

[4] 'Trips' are based on unlinked trips or individual trip legs.

[5] n = the sum of the normalised sample weights
Sample weights are applied but are normalised using a normalising factor (total sample count divided by population count). Outliers have been excluded in these tests of means.

[6] In these tests of difference in the means, a P value less than or equal to 0.05 indicates that the differences are statistically significant.

and Corpuz G 2009). The expansion of teleworking in this group of workers, especially in jobs that are best suited to the arrangement, may therefore be expected to generate the most benefits in easing peak pressures compared to other work schedules.

On the other hand, those with flexitime, variable hours and those with fixed hours (which vary each day) exert the least pressure during peak periods compared to other work schedules because of greater flexibility in the start and finish times (Shaz K and Corpuz G 2009). Among these groups were the highest proportions of teleworkers.

Table 7.1 Workers By Whether a Teleworker By Work Schedule, 2009

	Teleworker	Non-Teleworker	Total
Fixed start and finish times - same each day	35,000	896,000	931,000
	4%	*96%*	*100%*
Flexitime	6,000	50,000	56,000
	11%	*89%*	*100%*
Fixed start and finish times - each day can vary	44,000	380,000	424,000
	10%	*90%*	*100%*
Variable hours	86,000	508,000	594,000
	14%	*86%*	*100%*
Shift hours and others	2,000	285,000	287,000
	1%	*99%*	*100%*
Total	172,000	2,120,000	2,292,000
	8%	*92%*	*100%*

Note: Estimates are rounded to the nearest thousands but percentages are based on actual numbers.

7.2 Teleworking by job location and home to work distances

Workers in the Sydney CBD had the highest proportion of teleworkers (42,000 or 14%) (Table 7.2). This was followed by those who work in other centres[7] (62,000 or 10%). These are the areas that are comparatively better served by public transport. In comparison, workers in 'non-centres' which comprised the majority (1,370,000 or 60%) of all workers, had only 5% (68,000) teleworkers. These locations are comparatively not as well-served in terms of public transport and therefore had higher vehicle usage for the trip to work compared to those working in the CBD or other centres. Based on the 2006 Census data, the proportion of vehicle driver trips for the commute to work for jobs located in the CBD and other centres was 48% compared to 78% for the rest of Sydney or non-centre locations (TDC 2008). It should be noted though that this is influenced to some extent by the nature of jobs in these locations.

It will therefore be highly beneficial with respect to reduction in VKT (vehicle kilometres travelled) and resultant emissions to target jobs in non-centres for teleworking, taking into consideration the types of occupations and industries that are suitable. However, increasing teleworking for jobs based in CBD is still essential for the purpose of easing pressures on the public transport network.

[7] Centres as defined in transport and urban planning in Sydney (TDC 2008).

Table 7.2 Teleworkers by where they work, 2009

	Teleworker	Non-Teleworker	Total
Sydney CBD	42,000	257,000	300,000
	14%	*86%*	*100%*
Other Centres	62,000	561,000	623,000
	10%	*90%*	*100%*
Non-centre	68,000	1,302,000	1,370,000
	5%	*95%*	*100%*
Total	172,000	2,120,000	2,292,000
	8%	*92%*	*100%*

Note: Estimates are rounded to the nearest thousands but percentages are based on actual numbers.

Table 7.3 shows that based on the HTS, Sydney workers with home-to-work distances of over 20 kilometres comprised 27% of all workers (613,000 of 2,272,000 workers), but accounted for 35% of teleworkers (60,000 of 171,000 teleworkers). Teleworking in this group is of greater value as it avoids a longer trip, therefore, a higher proportion is the desired outcome. On average, teleworkers had a home-to-work distance of 19.7km, more than non-teleworkers with 15.6km. The difference was statistically significant.

Similar findings were reported by Ory and Mokhtarian (2005). Citing results from a State of California study, along with those from other studies, the authors concluded that telecommuters travelled longer distances to work than non-telecommuters. Dam et al (2009) had the same results from a study of 936 employees of a large, post secondary institution in Ontario, Canada.

Table 7.3 Teleworkers by home to work distances, 2009

	Teleworker	Non-Teleworker	Total
Up to 5km	31,000	523,000	554,000
5+ to 10km	32,000	466,000	499,000
10+ to 15km	27,000	337,000	364,000
15+ to 20km	22,000	221,000	243,000
Over 20km	60,000	553,000	613,000
	171,000	2,101,000	2,272,000
Average home to work distance	*19.7 km*	*15.6 km*	

Note: Estimates are rounded to the nearest thousands but percentages cited in the text are based on actual numbers. Column totals in this table are different to the other tables because of missing distances for some records.

The analysis is extended further here by examining the home-to-work distances of teleworkers who went to their usual place of work (as opposed to working from home) with the modes they used for their commute. Majority of teleworkers (71%, 61,000 of 87,000) went to work by private vehicle (Table 7.4). Twenty thousand of these 61,000 car commuters (32%) had home to work distances of over 20km. If just 20% of these teleworkers who went to work by car worked from home instead, VKT savings will be achieved, very roughly in the vicinity of 242,000 VKT per day based on an average home to work distances of 19.7km among teleworkers.

Considering the 23,000 teleworkers who took the train or bus to work, on the other hand, this much reduction of passengers in the network may also be realised, and this could be even more beneficial if the passenger trips are taken out of the peak periods.

Table 7.4 Teleworkers who did not work from home on their travel day By Home to work distance By Mode of travel to work, 2009

	Private vehicle only	Private vehicle and bus and/or train used	Bus and/or train used	None Of these	Total
Up to 5km	11,000	0	2,000	3,000	16,000
	67%	*1%*	*16%*	*16%*	*100%*
5+ to 10km	12,000	1,000	4,000	0	16,000
	72%	*4%*	*23%*	*1%*	*100%*
10+ to 15km	12,000	1,000	1,000	0	14,000
	83%	*8%*	*7%*	*2%*	*100%*
15+ to 20km	7,000	1,000	2,000	0	11,000
	69%	*8%*	*23%*	*0%*	*100%*
Over 20km	20,000	7,000	3,000	0	30,000
	66%	*23%*	*11%*	*0%*	*100%*
Total	61,000	10,000	13,000	3,000	87,000
	71%	*11%*	*15%*	*4%*	*100%*

Note: Estimates are rounded to the nearest thousands but cited percentages are based on actual numbers.

8. Summary and Discussion

The HTS analysis isolated the following important characteristics of teleworkers that may assist in policy development:

- those aged 31 to 50 years and those with higher incomes, which suggest maturity and experience as a worker; and
- managers, professionals and administrators

Additionally, the data indicated that teleworkers tend to be males more than females and belonging to couple households with children.

While those with access to teleworking were generally more mobile, on teleworking days they travelled less than other workers. The analysis indicated that on average, employees who worked from home made fewer trips overall, travelled shorter distances and generated less VKT than those that went to work. The comparison involved a test of difference in the means of two different groups of teleworkers, which meant that the extent of the difference was not necessarily an indication of the magnitude of the 'trip-reducing effect'. This analysis simply confirmed the fact that working from home was associated with lower trip-making. This is informative in itself for assessing its efficacy for demand management.

To measure the reduction effect more precisely, further studies may be undertaken that directly compare days in which the same group of teleworkers worked from home and when they went to work. Many analysts have already concluded that teleworking reduces trips (Zhoo et al 2009) but the effect appeared to be small especially at the per capita level. This small effect was attributed to its low incidence (Choo et al 2002). This indicates that key to realising the benefits will be in the expanded application of teleworking.

When considering extended implementation, it is worthwhile targetting areas where the potential for gains are higher. The analysis in this paper demonstrated that greater benefits, particularly in terms of reducing peak pressures, distance travelled (especially vehicle kilometres travelled) may be realised for workers with the following characteristics:

- Fixed hour work schedules with start times during the high demand 8-9am period
- Those working in non-centres
- Those with longer home-to-work distances, especially those who travel by private vehicle

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