The Effects of Compact Development on Travel Behaviour, Energy Consumption and GHG Emissions: Lessons from Neighbourhoods in Phoenix Metropolitan Area

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Introduction

Suburban growth in the U.S. urban regions has been defined by large subdivisions of single-family detached units. This growth is made possible by the mobility supported by automobiles and an extensive highway network. These dispersed, highly automobile-dependent developments have generated a large body of work examining the socioeconomic and environmental impacts of suburban growth on cities. The particular debate that this study addresses is whether suburban residents are more energy intensive in their travel behaviour than central city residents. If indeed suburban residents have needs that are not satisfied by the amenities around them, they may be travelling farther to access such services. However, if suburbs are becoming like cities with a wide range of services and amenities, travel might be contained and no different from the travel behaviour of residents in central areas. This paper compares the effects of long term suburban growth on travel behaviour, energy consumption, and GHG emissions through a case study of neighbourhoods in central Phoenix and the city of Gilbert, both in the Phoenix metropolitan region.

Study Area and Methodology

Our study is based on the change in travel behavior in the Phoenix Metropolitan area over the period 2001-2009. Phoenix metro is located in the state of Arizona in the southwest of the United States and encompasses an area of 11193.7 square miles. The motorized travel behaviour is analysed at the Transportation Analysis Zone (TAZ) level. Two specific study areas have been identified in this region that are located within the Phoenix urban core and in the suburban city of Gilbert, respectively. These areas are comparable in size but have different land use patterns and growth trajectories.

Motorized travel patterns for the metropolitan area will be generated using 2001 and 2009 National Household Travel Survey (NHTS) data by running the four-step transportation demand model *TRANSCAD*. The Home-based Work (HBW) and Home-based Shopping (HBSH) trips associated with the two selected study areas are extracted for further comparison. To analyse the travel patterns for those areas, the trips are classified into three types: 1) trips that originate and end within the study area, also called “intra” trips; 2) trips that originate outside each of the study areas but end in either of them, also called “Inter-in” trips; and 3) trips that originate in either of the study areas but end outside their boundaries, also called “Inter-out” trips. Energy consumption and GHG emission for each study areas are estimated based on the corresponding trip distribution results. Those final outcomes are then compared temporally between year 2001 and 2009 to see how the suburbanization within the metropolitan area over the last decade influenced travel, energy flow and GHG footprint. The flowchart in Figure 1 summarized the detailed research procedure followed by this paper.

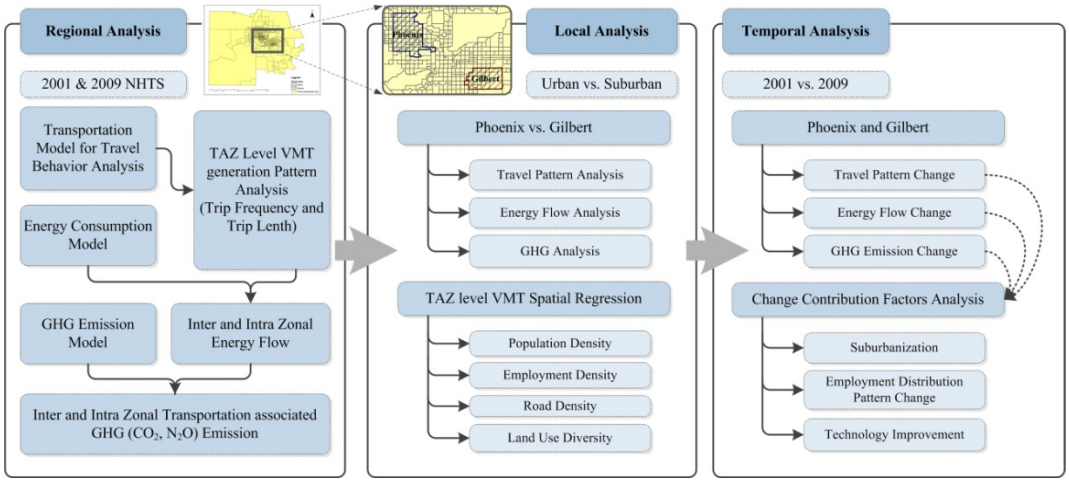

Figure 1: Research Flowchart

Study Results Analysis

The study results reveal that suburban living can significantly influence people's travel behaviour and energy use pattern. Based on the HBW results tabulated in Table 1 and 2, the average length of commuting trips increased from 2001 to 2009. The increasing distances of commute trips was also reflected in the decrease in intra-zonal trip frequencies and substantial increase in inter-zonal trips. While the inter-zonal trip frequencies increased substantially more in Gilbert compared to Phoenix, the trip lengths in Phoenix increased at a faster clip than the suburban area. The results also indicate that people living in the suburban area consume more energy and produce more GHG, which increased by about 100% over the study period.

Table 1: 2001 HBW Results Summary

2001 HBW Result Summary by Trip Types						
Trip Type	Zone	GHG (CO2e (kg))	Energy Consumption (Gallon of Gasoline)	Trip number	Trip/person	Avg. Trip Length
Intra	Phoenix	120491.57	13244.93	51926.01	0.15	4.12
Inter-out	Phoenix	324859.42	35709.88	56077.56	0.16	10.27
Inter-in	Phoenix	1613447.33	177356.76	190162.44	0.56	15.05
Intra	Gilbert	6192.33	680.69	3516.16	0.03	3.12
Inter-out	Gilbert	260290.29	28612.18	33923.24	0.29	13.61
Inter-in	Gilbert	75229.91	8269.58	10550.80	0.09	12.65
2001 HBW Result Summary						
Zone	GHG/Person	Energy/person	GHG/Trip	Energy/Trip	Trip/person	Avg. Trip Length
Phoenix	1.306	0.144	4.123	0.453	0.317	7.313
Gilbert	2.245	0.247	7.118	0.782	0.660	12.623

Table 2: 2009 HBW Results Summary

2009 HBW Result Summary by Trip Types						
Trip Type	Zone	GHG (CO2e (kg))	Energy Consumption (Gallon of Gasoline)	Trip number	Trip/person	Avg. Trip Length
Intra	Phoenix	136596.06	14943.91	18816.00	0.06	14.92
Inter-out	Phoenix	626737.16	68566.44	71352.00	0.21	18.06
Inter-in	Phoenix	2326873.22	254565.12	233406.48	0.68	20.49
Intra	Gilbert	12035.11	1316.67	3091.96	0.03	8.00
Inter-out	Gilbert	553641.25	60569.59	65236.97	0.55	17.45
Inter-in	Gilbert	290799.75	31814.14	31602.58	0.27	18.92

2009 HBW Result Summary						
Zone	GHG/Person	Energy/person	GHG/Trip	Energy/Trip	Trip/person	Avg. Trip Length
Phoenix	2.239	0.245	8.466	0.926	0.264	17.403
Gilbert	4.765	0.521	8.279	0.906	0.576	17.019

The suburbanization of retail service reversed the shopping travel pattern for urban and suburban inhabitants during the last decade, as shown in Table 3 and 4. In 2001 Phoenix central city inhabitants generated more shopping trips per person. While in 2009, due to the rise of retail service within the suburban area, the average length of shopping trips generated within Gilbert area dropped from 7.5 miles to 6.7 miles. Meanwhile, the trip frequency for Gilbert residents increased from 0.376 per person to 1.002 per person. Such variation in travel pattern, however, didn't change the fact that suburban residents tend to consume more energy. However, it should also be noted that the difference in energy consumption between Phoenix and Gilbert study areas declined from 2001 to 2009.

Table 3: 2001 HBSH Results Summary

2001 HBSH Result Summary by Trip Types						
Trip Type	Zone	GHG (CO2e (kg))	Energy Consumption (Gallon of Gasoline)	Trip number	Trip/person	Avg. Trip Length
Intra	Phoenix	149278.23	16409.28	98187.33	0.29	2.70
Inter-out	Phoenix	201070.92	18825.34	41219.02	0.12	7.37
Inter-in	Phoenix	1083876.94	119144.21	132648.58	0.39	14.49
Intra	Gilbert	12259.86	1347.65	10651.79	0.09	2.04
Inter-out	Gilbert	176503.06	19401.94	33984.48	0.29	9.21
Inter-in	Gilbert	46359.19	5095.99	8884.88	0.07	9.25

2001 HBSH Result Summary						
Zone	GHG/Person	Energy/person	GHG/Trip	Energy/Trip	Trip/person	Avg. Trip Length
Phoenix	1.027	0.103	2.513	0.253	0.409	4.078
Gilbert	1.590	0.175	4.229	0.465	0.376	7.500

Table 4: 2009 HBSH Results Summary

2009 HBSH Result Summary by Trip Types						
Trip Type	Zone	GHG (CO2e (kg))	Energy Consumption (Gallon of Gasoline)	Trip number	Trip/person	Avg. Trip Length
Intra	Phoenix	116544.37	12750.21	55789.03	0.16	4.29
Inter-out	Phoenix	818366.94	89531.17	190634.80	0.56	8.82
Inter-in	Phoenix	1151502.54	125976.94	228443.42	0.67	10.36
Intra	Gilbert	29806.01	3260.84	17601.10	0.15	3.48
Inter-out	Gilbert	359861.19	39369.62	101290.34	0.85	7.30
Inter-in	Gilbert	381237.99	41708.29	79504.78	0.67	9.86

2009 HBSH Result Summary						
Zone	GHG/Person	Energy/person	GHG/Trip	Energy/Trip	Trip/person	Avg. Trip Length
Phoenix	2.742	0.300	3.794	0.415	0.723	7.799
Gilbert	3.282	0.359	3.278	0.359	1.002	6.738

The results from the study of HBW and HBSH trips also suggest that travel behavior for urban and suburban inhabitants in the Phoenix metropolitan region are converging around longer travel distances and higher energy use. While central city residents are not confining themselves to the jobs, shopping, and service opportunities available closeby, suburban residents are finding more options to travel both near and far. Although increasing land use diversity in the suburban area can induce more intra-zonal trips, it does not seem to be a check for the growth of inter-zonal trips that are increasing at a faster clip. Conversely, the density of developments in the urban core has not been instrumental in limiting growth in inter-zonal trips of Phoenix residents. More analytical models will be tested to see whether and how urban form influences travel behavior and energy use in future research.

Conclusions

The results from this study reveal that suburban growth does have an impact on people's travel behaviors. As suburbs grew and diversified, the difference in travel behavior between people living in suburban and urban areas became smaller. In the case of shopping trips the average length of trips for suburban residents in 2009 was slightly shorter than that for central city residents. This convergence was substantially due to the faster growth in trip lengths for central city compared to suburban residents in the 8-year period. However, suburban residents continue to be more energy intensive in their travel behavior, as the effect of reduction in trip length is likely to be offset by the more intensive growth in trip frequency. Additionally, overall energy consumption has grown significantly in both study areas over the period of study.

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