# Urban Travel and Urban Population Density

Wendell COX

## *Abstract*

*It is often assumed that lower density cities have longer average work trip travel times and greater traffic congestion than more compact cities. This paper summarises available data with regard to the association between urban densities and work trip travel times as well as between urban densities and the intensity of traffic congestion. The analysis indicates that higher urban densities are associated with both longer work trip travel times and greater traffic congestion (Figure 1). Because greater access is associated with more favourable urban economic outcomes, a greater focus on access seems advisable. This is all the more likely because of emerging research indicating that compact cities policies produce only modest GHG emission reductions.*

***Figure 1: The dense city of Athens, Greece, is grappling with issues of traffic congestion***

## Introduction

It has been claimed that greater traffic congestion and longer average work trip travel times are associated with lower density cities (which as used herein are urban areas and their associated metropolitan areas[1]). This can be seen in research (Surface Transportation Policy Partnership 1999), the claims of environmental activists (Sierra Club n.d.) and is often cited in local planning presentations. At the same time, however, a body of research suggests the opposite relationship—that more dispersed cities are characterised by less intense traffic congestion and that commuting times are shorter (Gordon, Richardson and Wong 1985). This result can be explained by the co-location of employers and employees *(Figure 2)*. Further, it is widely assumed that the larger physical

***Figure 2: In less dense cities like Cincinnati, employers are more likely to be co-located with employees***

expanses of lower density cities force people to travel longer to work and other destinations, though there is evidence to suggest that the opposite is true.

The issue has taken on heightened importance as a result of policy efforts to restrict density of urbanisation (loosely called "urban sprawl") to address greenhouse gas (GHG) emission reduction objectives. Generally, policies (sometimes called "smart growth", "growth management", and "compact city" policies) that force higher densities and suppress

**...more dispersed cities are characterised by less intense traffic congestion and that commuting times are shorter...**

automobile use (hereinafter referred to as "densification policy") are seen as critical among urban planners to achieve sufficient GHG emission reductions.

However, the analysis to support such a position is tenuous. A recent study published in the Journal of the American Planning Association (Echenique et al. 2012) concluded that "compact development should not automatically be associated with the preferred spatial growth strategy" and that its impact on energy consumption and land use is "very modest". The McKinsey Company and The Conference Board (2007) concluded that strategies such as these were not required to cost-effectively achieve sufficient GHG emission reductions in the United States.

**...it is widely assumed that the larger physical expanses of lower density cities force people to travel longer to work and other destinations, though there is evidence to suggest that the opposite is true.**

This is confirmed by our review (Cox 2011) of major US studies on the long-term impacts of densification policies. Nearly all of the expected GHG emission reductions are projected to be from improvements in automobile fuel economy, a factor unrelated to densification policies.

Thus, this research involves a study of international cross-section data to test whether densification policies are likely to result in material contributions toward sufficient GHG emission reductions. In view of the importance of economic growth and job creation around the world, the nexus between better metropolitan access and household affluence warrants serious attention.

**Nearly all of the expected GHG emission reductions are projected to be from improvements in automobile fuel economy, a factor unrelated to densification policies.**

## The Importance of Access

Nearly everyone agrees that, other things equal, less traffic congestion and shorter travel times are preferable. Prud'homme and Lee (1998), Cervero (2000), Hartgen and Fields (2009) and others have shown that where access within a fixed time (such as 30 minutes) is maximised, economic growth is greater. Notably, the recent Rio +20 conference concluded that, "Eradicating poverty is the greatest global challenge facing the world today and an indispensable requirement for sustainable development".

**...where access within a fixed time (such as 30 minutes) is maximised, economic growth is greater.**

Further, according to the American Heart Association, greater traffic congestion produces more intense local air pollution adjacent to highly trafficked corridors, which is associated with negative health consequences (Brook et al. 2004) *(Figure 3)*.

***Figure 3: Air pollution is of great concern in Hong Kong, a city well known for highly trafficked corridors***


## Analysis

The international data on traffic congestion are far from ideal. Yet, there are sufficient data available to allow provisional analyses that can in the future be taken farther as the data improve. This paper examines the related issues of journey to work travel time, and traffic congestion in relation to urban density. The journey to work data are taken from sources such as Eurostat, the United States Census Bureau and Statistics Canada. The traffic congestion data are taken from the INRIX traffic scorecard (n.d.) which uses satellite technology to measure the intensity of traffic congestion in approximately 200 metropolitan areas of Europe, Canada and the United States. The urban density data are from our *Demographia World Urban Areas* (Cox 2012a), which includes population, urban land area, and average density estimates for all identified urban areas in the world with 500,000 or more residents.

### *Average Urban Density and Journey to Work*

Because most work trips occur in a restricted window of time, they are the most subject to highway congestion. Other things being equal, and consistent with the "access" research cited here, a city is likely to be better off economically where work trip travel durations are shorter.

We were able to locate average one-way work trip travel times for 109 metropolitan areas with more

***Table 1: Multiple Linear Regression Analysis: International Journey to Work Travel Time "Analyse-It" Output (XLS Addon Software, Elasticity Added)***

| | |
|---|---|
| n | 109 |
| $R^2$ | 0.68 |
| Adjusted $R^2$ | 0.660 |
| SE | 3.0 |

| Term | Coefficient | 95% CI | SE | t statistic | DF | p | ELASTICITY |
|---|---|---|---|---|---|---|---|
| Intercept | 21.95 | 20.89 to 23.02 | 0.538 | 40.84 | 103 | < 0.0001 | |
| DENS/KM | 0.0006738 | 0.0003765 to 0.0009711 | 0.00014990 | 4.49 | 103 | < 0.0001 | 0.064 |
| POP | 6.0900E-07 | 4.5037E-07 to 7.6763E-07 | 7.9984E-008 | 7.61 | 103 | < 0.0001 | 0.083 |
| EUR | 1.005 | -0.344 to 2.354 | 0.6802 | 1.48 | 103 | 0.1426 | |
| CAN/AUS | 4.252 | 1.860 to 6.643 | 1.2059 | 3.53 | 103 | 0.0006 | |
| ASIA | 1.522 | -2.863 to 5.907 | 2.2110 | 0.69 | 103 | 0.4928 | |

JTW = 21.95 + 0.0006738DENS/KM + 6.0900E-007POP + 1.005EUR + 4.252CAN/AUS + 1.522ASIA

| Source of variation | Sum squares | DF | Mean square | F statistic | p |
|---|---|---|---|---|---|
| Model | 1908.7 | 5 | 381.7 | 42.90 | < 0.0001 |
| Residual | 916.6 | 103 | 8.9 | | |
| Total | 2825.3 | 108 | | | |

**...a city is likely to be better off economically where work trip travel durations are shorter.**

than 1 million population in affluent Asia, Australia, Canada and the United States. A linear regression analysis was performed to identify any association between average urban population density and average journey to work travel time, which was the dependent variable. The independent variables tested were metropolitan area population, average density of the principal urban area (the largest urban area in the metropolitan area), along with dummy variables for major regions (Asia, Australia, Canada, and Europe, with the United States as the base case).

As expected, urban area population density and population are highly significant *(Table 1)*. Along with the dummy variables, the simple model explains 66 percent of the average commute time variation (adjusted R2 of 0.660), which is statistically significant at the 99 percent level of confidence.[2] Both population and population density were statistically significant at the 99 percent level of confidence. The elasticities of the two independent variables were roughly similar, with the one associated with population variable being slightly higher.

While the dummy variables for Europe and Asia were not statistically significant, the Canadian dummy variable was statistically significant at the 99 percent level of confidence.

There are always caveats in this type of testing. It would have been preferable to include additional variables, such as the capacity of the roadway systems. However, the state of the international data did not permit this. Moreover, the data are for a variety of years. Finally, while the journey to work travel times and metropolitan area populations

***Table 2: Multiple Linear Regression Analysis: International Traffic Congestion "Analyse-It" Output (XLS Addon Software, Elasticity Added)***

| | |
|---|---|
| n | 187 |
| $R^2$ | 0.35 |
| Adjusted $R^2$ | 0.347 |
| SE | 6.83 |

| Term | Coefficient | 95% CI | SE | t statistic | DF | p | ELASTICITY |
|---|---|---|---|---|---|---|---|
| Intercept | 5.817 | 4.028 to 7.605 | 0.9066 | 6.42 | 184 | < 0.0001 | |
| POP | 1.0024E-06 | 5.7386E-07 to 1.4310E-06 | 2.1722E-007 | 4.61 | 184 | < 0.0001 | 0.14 |
| DENS/KM | 0.002952 | 0.002237 to 0.003668 | 0.0003628 | 8.14 | 184 | < 0.0001 | 0.42 |

TRCONGIX = 5.817 + 1.0024E-006POP + 0.002952DENS/KM

| Source of variation | Sum squares | DF | Mean square | F statistic | p |
|---|---|---|---|---|---|
| Model | 4715.23 | 2 | 2357.62 | 50.51 | < 0.0001 |
| Residual | 8587.81 | 184 | 46.67 | | |
| Total | 13303.04 | 186 | | | |

are for the same time period, the average density figure is current, simply because comparable earlier data are not generally available. However, urban densities tend to fluctuate much less than the general increase in metropolitan populations, which would suggest that that does not create material distortion.

The conclusion it suggests is that there is good evidence to support the idea of strong links between higher population densities and longer journey to work travel times.

**...there is good evidence to support the idea of strong links between higher population densities and longer journey to work travel times.**

## *Average Urban Density and Traffic Congestion*

A related test involved a measure of highway congestion. The INRIX traffic congestion data estimate the additional roadway travel time that is necessitated by the more intense traffic congestion in peak travel times. An index is provided, which is the additional travel time as a percentage of the expected travel time in the absence of traffic congestion.

The available INRIX data on traffic congestion are more geographically limited to Canada, Europe and the United States, but include more metropolitan areas. The test described here included all 187 metropolitan areas with 500,000 or more population for which data was available.[3]

The INRIX traffic congestion index is the dependent variable while metropolitan area population and average urban density are the independent variables *(Table 2)*. Again, a plausible value for proportion of explained variation of 35 percent was found (adjusted R2 0.347), which was statistically significant at the 99 percent level of confidence. Both higher population and higher population density were associated with greater

***Figure 4: Densely built Milan displays a higher INRIX traffic congestion index***

traffic congestion (a higher INRIX traffic congestion index) and were also statistically significant at the 99 percent level of confidence *(Figure 4)*.

Looking at the elasticities, the association between population density and the traffic congestion index was three times as strong as the association with population. The overall INRIX regional averages show US traffic congestion to be materially below that of Europe and Canada, as is indicated in *Table 3*.

***Table 3 : Traffic Congestion Averages***

| | Cases (Metropolitian Areas) | Average Metropolitian Area | Density (Population per km²) | Traffic Congestion Index |
|---|---|---|---|---|
| **Canada** | 5 | 2,834,200 | 2,081 | 17.6 |
| **Europe** | 82 | 1,678,806 | 3,042 | 18.8 |
| **United States** | 100 | 2,015,000 | 1,009 | 8.8 |

The data sample is strongly weighted toward the United States, which, with its lower density urban areas, accounts for 100 of the 187 cases. When a dummy variable for the US is added to the regression, the influence of the United States is even stronger. The adjusted R2 rises to 0.485. This indicates the likelihood that there may be more about the US cities than simply lower average density that is driving their lower rates of traffic congestion. Additional factors may include the more comprehensive roadway systems in the United States and the more dispersed distribution of employment.

**...there may be more about the US cities than simply lower average density that is driving their lower rates of traffic congestion. Additional factors may include the more comprehensive roadway systems in the United States and the more dispersed distribution of employment.**

For example, Gordon and Lee (2012) have shown that work trip travel times in the United States are shorter to dispersed employment locations than to central business districts or secondary business centres (such as "Edge Cities"). This could indicate that US metropolitan areas are developing market-driven jobs – housing balances, the spontaneous outcome of more liberal land-use regulatory regimes.

Thus, the conclusion of this analysis is that US metropolitan areas have less intense traffic congestion than their peer areas. Their lower population densities contribute to this, but do not completely explain the difference.

## *The Role of Mass Transit*

This analysis has purposefully excluded any discussion of mass transit and focuses on highways in the traffic congestion analysis only because individual road transportation represents the majority of travel in virtually all major high-income world metropolitan areas, with the exceptions of Osaka–Kobe–Kyoto, Tokyo–Yokohama and Hong

Kong. There are obviously trips that are faster, door-to-door by mass transit, such as to some of the largest central business areas. This research, however, is concerned with maximising overall access to obtain improved economic performance. Mode is thus not a principal consideration.

**This analysis has purposefully excluded any discussion of mass transit and focuses on highways in the traffic congestion analysis only because individual road transportation represents the majority of travel in virtually all major high-income world metropolitan areas...**

## *Discussion*

While these conclusions may appear to contradict much of the popular thinking on cities and density, the relationship between higher population densities and greater traffic congestion has been found in other research.

**...the relationship between higher population densities and greater traffic congestion has been found in other research.**

Despite a position that avers lower densities increase traffic congestion, Sierra Club research (ICLEI n.d.) [4] indicates that a doubling of residential density would be associated with at least a 60 percent increase in vehicle travel. Thus, in a densifying (fixed) area, traffic volumes would rise and congestion would be worsened. Ewing and Cervero (2010) analysed a number of reports on density and vehicle usage and found, on average, a minus 0.04 elasticity. This indicates that as density rises, traffic volumes rise at 96 percent as much as the increased density rate.

**...as density rises, traffic volumes rise at 96 percent as much as the increased density rate.**

These findings are supported by examinations of actual travel behaviour. A Statistics Canada report (Turcotte 2008) found that in residential areas more than 10 kilometres from the CBD, differences in housing density account for virtually no difference in travel behaviour, with residents of high rise multi-unit neighbourhoods having similar travel patterns to residents of neighbourhoods made up principally of detached and semi-detached housing. McCloskly, Birrell and Yip (2009) suggested that siting new housing near tram and rail stations/stops was not likely to materially change travel patterns, since a small share of current residents in such areas commuted by mass transit. This, they found, was due to the substantial dispersion of jobs, most of which were practically accessible only by car. In each of these situations, densification would lead to greater traffic congestion.[5]

A comparison of the Toronto and Dallas–Fort Worth urban areas also illustrates the point. According to the recent national censuses, these two urban areas had virtually the same population. However, Toronto had the highest urban population density in either Canada or the United States, at 2, 950 per square kilometre. The Dallas–Fort Worth urban population density was 1,100, which is approximately the United States average.[6] Yet, the average work trip travel time in Toronto is longer than in Dallas–Fort Worth (26 minutes versus 33 minutes). Further, the traffic congestion in Dallas–Fort Worth is less

***Table 4 : Toronto & Dallas-Fort Worth Indicators***

| Indicator | Toronto | Dallas - Fort Worth | Toronto / Dallas- Fort Worth |
|---|---|---|---|
| **Population (Population Centre/Urban Area)** | 5,132,794 | 5,121,892 | 0% |
| **Land Area (km²)** | 1,751 | 4,606 | -62% |
| **Density** | 2,931 | 1,112 | 164% |
| **One Way Work Trip** | 33 | 26 | 27% |
| **Reach Work in 30 Minutes** | 48% | 59% | -19% |
| **Traffic Congestion Index** | 17.4 | 13.0 | 34% |

intense than in Toronto. Dallas–Fort Worth has a traffic congestion index of 13.0, compared to 17.3 in Toronto *(Table 4)*.[7]

Further, among the megacities[8] in the journey to work sample, Los Angeles had the lowest average density (2, 700 per square kilometre) and the shortest work trip travel times.[9]

**...among the megacities in the journey to work sample, Los Angeles had the lowest average density (2, 700 per square kilometre) and the shortest work trip travel times.**

## *Limitations*

These conclusions will have less practical value in the few severely land constrained metropolitan areas of the world. Among the larger metropolitan areas, Singapore would be the best example, with virtually no rural periphery to develop. In this unusual environment, population growth necessarily leads to increased population density, the very opposite of continuing trends. Our "Evolving Urban Form" series shows that suburban, lower density population tends to predominate in major urban areas of the higher-, middle- and lower-income worlds (Cox 2011 and 2012).[10] Singapore has responded to this unique challenge with a comprehensive road pricing system, which has not been politically achievable elsewhere. There have also been intensive mass transit improvements, which would be difficult to replicate in all but the most dense urban areas because of prohibitive costs and more dispersed employment patterns.

**These conclusions will have less practical value in the few severely land constrained metropolitan areas of the world.**

Hong Kong faces similar, but less severe difficulties, with some peripheral land that can be developed. Moreover, there is the potential in the longer run for integration into a larger metropolitan structure, with more land for development, that could include Shenzhen and might stretch through Dongguan to Guangzhou-Foshan and perhaps encompass the entire Pearl River Delta.[11]

## *Conclusion*

With densification policy not being an environmental imperative, the urban planning community can be freed to focus on the principal purpose of cities. Cities are economic organisms. They grow principally by attracting people seeking economic betterment. Thus, it is important for urban policies to encourage economic opportunity and growth, and thereby to increase the discretionary incomes of households.

Access throughout the metropolitan area is important to improving economic growth. It seems likely that cities will better perform their key economic functions if policy is focused toward getting people (and also goods) to where they want to go (and where they are most highly valued) as rapidly as possible. Understanding associations between journey to work travel times, traffic congestion and the important urban density is, therefore, important to the many people who benefit from economic growth and development.

### Notes

1. Urban areas are areas of continuous urban development, such as defined by the US Census Bureau or France's INSEE ("unités urbaines"). Metropolitan areas are labour markets, which include the urban area and economically connected areas, such as rural areas and smaller urban areas (called "aires urbaines" by INSEE).

2. The average work trip travel time in Tokyo–Yokohama, Osaka–Kobe–Kyoto and Nagoya was estimated from a distribution of travel times available from the Japan Statistical Yearbook.

3. The INRIX database includes smaller metropolitan areas (less than 500,000 population) only in Europe.

4. This source is a "density" vehicle travel calculator, which relies on Sierra Club research. The traffic increase referenced is calculated from the source by the author.

5. Mass transit access was found to be astonishingly low in US metropolitan areas, based upon Tomer, et al. (2011), whose data shows that the average major metropolitan area (1,000,000 and over population) resident can reach only six percent of jobs in 45 minutes on mass transit (author's calculations). The greatest accessibility was in Milwaukee, at 13 percent, while in Portland, renowned for its compact city policies, the figure was 8 percent. By comparison, the average one-way work trip in the United States is approximately 25 minutes.

6. The urban density of Dallas–Fort Worth is near the national large urban area average of 1,200. By comparison, Portland, with its reputation as a densification policy leader, has a density of 1,350 per $km^2$ and Los Angeles, the most dense major urban area in the US, has a density of 2,700 per $km^2$.

7. Toronto's housing costs relative to household incomes have risen strongly since adopting densification policy. On the other hand, Dallas–Fort Worth, with liberal land use regulation, has since had little or no increase in house costs relative to incomes (Cox and Pavletich, *Demographia International Housing Affordability Surveys*, 2005–2012). A description of the association between compact city policies and the loss of housing affordability is provided at Cox (2012b).

8. Over 10 million population.

9. The other megacities were Tokyo–Yokohama, Seoul–Incheon, Osaka–Kobe–Kyoto, Paris and London. Paris was the closest to Los Angeles in density (25 percent more dense) and in work trip travel time (seven minutes more).

10. The series has examined approximately 30 large urban areas, including nearly all of the world megacities (over 10 million population).

11. These adjacent urban areas already have a population greater than that of the Tokyo–Yokohama urban area and cover a smaller land area (calculated from *Demographia World Urban Areas*).

### References

Brook, R. D., B. Franklin, W. Cascio, Y. Hong, G. Howard, M. Lipsett, R. Luepker et al. 2004. Air Pollution and Cardiovascular Disease: A Statement of the Health Care Professionals from the Expert Panel on Population and Prevention Science of the American Heart Association. *Circulation,* 109: 2655–2671.

Cervero, R. 2000. Efficient Urbanization: Economic Performance and the Shape of the Metropolis. *Lincoln Institute of Land Policy Working Paper.* http://www.lincolninst.edu/pubs/88_Efficient-Urbanization.

Cox, W. 2011. *Reducing Greenhouse Gases from Personal Mobility: Opportunities and Possibilities.* Los Angeles: Reason Foundation.

———. 2012a. *Demographia World Urban Areas: 8th Edition.* Demographia. http://demographia.com/db-worldua.pdf.

———. 2012b. *Prescriptive Land Use Regulation and Higher House Prices: Literature Review on Smart Growth, Growth Management, Livability, Urban Containment and Compact City Policy.* Demographia. http://demographia.com/db-dhi-econ.pdf.

———. 2011, 2012. *The Evolving Urban Form: Development Profiles of World Urban Areas.* newgeography. http://www.newgeography.com/category/story-topics/evolving-urban-form (index).

Cox, W. and H. Pavletich. 2012. 8th *Annual Demographia International Housing Affordability Survey.* http://www.demographia.com/dhi.pdf.

Echenique, M. L., A. J. Hargreaves, G. Mitchell and A. Namdeo. 2012. Does Urban Form Really Matter? *Journal of the American Planning Association,* 78(2): 121–137

Ewing, R. and R. Cervero. 2010. Travel and the Built Environment. *Journal of the American Planning Association*, Volume 76, Issue 3.

Gordon, P. and B. Lee. 2012. Spatial Structure and Travel: Trends in Commuting and Non-Commuting Travels in US Metropolitan Areas, draft chapter for the *International Handbook on Transport and Development,* ed. Robin Hickman, David Bonilla, Moshe Givoni and David Banister.

Gordon, P., H. W. Richardson and H. L. Wong. 1985. The distribution of population and employment in a polycentric city: the case of Los Angeles. *Environment and Planning.* http://ideas.repec.org/a/pio/envira/v18y1986i2p161-173.html

Hartgen, D. T. and M.G. Fields. 2009. *Accessibility, Traffic Congestion and Regional Economic Performance.* Reason Foundation. http://reason.org/news/show/gridlock-and-growth-the-effect.

ICLEI. n.d. *ICLEI Density-VMT Calculator.* http://www.icleiusa.org/library/documents/8-Density-VMT%20Calculator%20%282%29.xls/view.

INRIX. n. d. *Traffic Congestion Scorecard.* http://scorecard.inrix.com/scorecard/,

McCloskly, D., B. Birrell and R. Yip. 2009. Making Public Transport work in Melbourne. *People and Place*, 17(3): 49–59.

Prud'homme, R. and C. W. Lee. 1998. *Size, Sprawl, Speed, and the Efficiency of Cities.* Observatoire de l'Économie et des Institutions Locales.

Rio +20. 2012. The Future We Want. United Nations Conference on Sustainable Development, June 20–22, in Rio de Janeiro, Brazil. http://www.uncsd2012.org/content/documents/727The%20Future%20We%20Want%2019%20June%201230pm.pdf.

Sierra Club. n.d. *Population Growth and Suburban Sprawl: A Complex Relationship.* http://www.sierraclub.org/sprawl/whitepaper.asp.

Surface Transportation Policy Partnership. 1999. *Sprawl as a Primary Cause of Congestion.* http://www.transact.org/report.asp?id=73

Tomer, A., E. Kneebone, A. Berube and R. Puentes. 2011. *Missed Opportunity: Transit and Jobs in Metropolitan America.* Washington, D.C.: Brookings Institution.

Turcotte, M. 2008. Life in metropolitan areas: Dependence on cars in urban neighbourhoods. *Canadian Social Trends.* Statistics Canada. http://www.statcan.gc.ca/pub/11-008-x/2008001/article/10503-eng.pdf.

Wendell Cox is principal of Demographia, a public policy firm in St. Louis, USA. He was a three-term member of the Los Angeles County Transportation Commission and a one-term member of the Amtrak Reform Council. He also served nine years as a visiting professor at the Conservatoire National des Arts et Metiers in Paris and is Vice-President of CODATU, which conducts conferences and research on improving transport in developing world cities. He also chaired two American Public Transit Association committees. His principal research interests have been international demographics, land use policy, urban mass transit, and intercity passenger transport. He is author of the annual *Demographia World Urban Areas* and co-author of the annual *Demographia International Housing Affordability Survey*.