The built environment and active travel

Influences on GHG emissions, community connections, and paradoxes in intensification

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Overview

• Paradox of intensification
• Travel Behaviour, Built Environment (BE), and Lifecycle Stages (LCS)
• Greenhouse gases, BE, and LCS
• Children in Compact Development
• Time Use
Paradox of Intensification

Photo: cycle.ottawacitizen.com
Paradox of Intensification

- Term coined by Melia et al. 2011\(^1\).
- Ceteris paribus, *urban intensification which increases population density will reduce per capita car use, with benefits to the global environment, but will also increase concentrations of motor traffic, worsening the local environment in those locations where it occurs.*
### Very Simple Example of Concept

<table>
<thead>
<tr>
<th>Area Name</th>
<th>Population</th>
<th>VKT/capita (km/year)</th>
<th>Local car trips/day</th>
<th>Percentage of trips by car</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10 000</td>
<td>10 000</td>
<td>20 000</td>
<td>50%</td>
</tr>
<tr>
<td>B</td>
<td>5000</td>
<td>15 000</td>
<td>15 000</td>
<td>75%</td>
</tr>
<tr>
<td>C</td>
<td>2500</td>
<td>20 000</td>
<td>10 000</td>
<td>100%</td>
</tr>
</tbody>
</table>

GLOBAL Impact: Average VKT/capita = 12 900 km/year
Area C Redistributed, Densification

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</thead>
<tbody>
<tr>
<td>A_c</td>
<td>11 250</td>
<td>10 000</td>
<td>22 500</td>
<td>50%</td>
</tr>
<tr>
<td>B_c</td>
<td>6250</td>
<td>15 000</td>
<td>18 750</td>
<td>75%</td>
</tr>
</tbody>
</table>

- **GLOBAL IMPACT**: Average VKT/capita = 11 800 km/year
  - Reduction of − 8%
- **LOCAL IMPACT** (local trips by car):
  - Area A = + 13%
  - Area B = + 25%
- Individual’s local experience may be worse.
Too simple?

• The density increased, surely that would have *some* impact?
• Congestion increase = reduced utility in car use.
• Increase in service density (concentration of customers) = increased utility of non-motorised modes.
• Increased population density = increased public transportation utility through improved service ("economies of density")
Return to the Simple Example

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<td>10 000</td>
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</table>

- Assume each Area is the same size.
- Linear regression provides a relation:
  - \( VKT = -1.3 \times \text{Population (density)} + 22 500 \)
  - \( \% \text{ car trips} = -0.00006 \times \text{Pop. (den)} + 1.125 \)
## New State

<table>
<thead>
<tr>
<th>Area Name</th>
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</thead>
<tbody>
<tr>
<td>A_c</td>
<td>11 250</td>
<td>8 036</td>
<td>20 250</td>
<td>45%</td>
</tr>
<tr>
<td>B_c</td>
<td>6250</td>
<td>14 464</td>
<td>18 750</td>
<td>75%</td>
</tr>
</tbody>
</table>

• Compared to previous:

<table>
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</tbody>
</table>
New State Impacts

- GLOBAL IMPACT: - 20% in VKT/capita
- LOCAL IMPACT:
  - Area A = - 4% local trips by car
  - Area B = 14% local trips by car
- Threshold effect could lead to actual improvements in both Global and Local conditions.
Further Considerations

• The people who have already settled into their habits may be less likely or slower to change their travel patterns.

• New arrivals may be more likely to adjust to the actual conditions (and not just what they’ve become accustomed to doing).

• Young people who grow up in the new conditions may be more likely to respond.

• Paradox: those not producing the pollution, suffer the pollution of others?
Travel Behaviour and the Built Environment

Photo: Owen Waygood, 2006
Travel Behaviour and the Built Environment (BE)

• One review of BE’s impact on travel behavior in the US found that it explained distance and trip frequency, but that socio-economic factors were equally important in explaining mode use.²

• But in the US (and Canada), are we comparing “car friendly” versus “car dependent”? Is there a real example of a balanced transportation system where choice generally exists?
Cycling in Tokyo

- Video of bicycle ride through Tokyo:
Japanese Planning

- Based on German system.
- Areal rather than linear.
- Mixed use:
  - within blocks and
  - vertically.
- Sidewalks only on arterial roads.
- Bicycle lanes have only recently been introduced.
Common “knowledge”

• Need sidewalks for pedestrians.
• Need bicycle lanes for cyclists.
• So, Japan should have low walking and cycling rates...
Five Built Environments

(Results from Sun et al., 2009\textsuperscript{7})
Highly Commercial
Mixed Commercial
Mixed Residential
Autonomous
Unurbanized
Overall Modal Share for Year 2000

- Private motor
- Public transport
- Walk
- Bicycle

<table>
<thead>
<tr>
<th>Category</th>
<th>Private Motor</th>
<th>Public Transport</th>
<th>Walk</th>
<th>Bicycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Commercial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed Commercial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed Residential</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autonomous</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q? How has the modal share changed over 40 years?

• Japan has experienced tremendous change in their economic status over the past 40 years.
  – Tremendous growth until the early 1990s.
  – “Bubble burst” in the early 1990s.
  – Stagnated economy following that.

• Built environment of periphery has become more car-orientated.
<table>
<thead>
<tr>
<th></th>
<th>Highly Commercial</th>
<th>Mixed Commercial</th>
<th>Mixed Residential</th>
<th>Autonomous</th>
<th>Undeveloped</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOUSEHOLD SIZE</td>
<td>2.2</td>
<td>2.5</td>
<td>2.9</td>
<td>3.1</td>
<td>3.3</td>
</tr>
<tr>
<td>HH CARS</td>
<td>0.49</td>
<td>0.623</td>
<td>1.11</td>
<td>1.63</td>
<td>1.82</td>
</tr>
<tr>
<td>HH MOTORCYCLES</td>
<td>0.15</td>
<td>0.17</td>
<td>0.3</td>
<td>0.45</td>
<td>0.5</td>
</tr>
<tr>
<td>HH BICYCLES</td>
<td>1.13</td>
<td>1.44</td>
<td>1.34</td>
<td>1.36</td>
<td>0.92</td>
</tr>
<tr>
<td>POPULATION DENSITY</td>
<td>8985 (4224 to 12594)</td>
<td>12620 (5493 to 18757)</td>
<td>3770 (48 to 16114)</td>
<td>1138 (74 to 2457)</td>
<td>493 (35 to 1976)</td>
</tr>
<tr>
<td>(PEOPLE/KM²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SERVICE DENSITY</td>
<td>558 (222 to 1137)</td>
<td>189 (97 to 776)</td>
<td>38.1 (0 to 208)</td>
<td>15 (0.6 to 25)</td>
<td>4 (0.5 to 15)</td>
</tr>
<tr>
<td>(BUSINESSES/KM²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Household Automobile-Use by Built Environment Type over Four Decades
Summary of Trend

• Higher density areas saw less growth in automobile’s share of trips.
• Most urban areas showed little to no growth.
• Is it because young families move out and only the older people who grew-up walking remain?
• Here, we need to know the household types.
Household Lifecycle Stages

- Younger single
- Younger childless couple
- Pre-school nuclear
- Young school nuclear
- Older school nuclear
- All adults
- Older childless couple
- Older single
- Single parent
- Others
Household Automobile-Use by Lifecycle across the Built Environments (2000)
Household Trip Number by Lifecycle across the Built Environments (2000)
Household Trip Number by Lifecycle across the Built Environments (2000)

- Younger single
- Young school nuclear
- All adults

- Highly Commercial area
- Mixed Commercial area
- Mixed Residential
- Autonomous area
- Unurbanized area
Summary of results

• Household lifecycle stage quite clearly determines the number of trips performed by a household, but

• ANOVA analysis confirms that the *Built Environment* has a stronger effect on mode choice than the household lifecycle stage.
  – Social-demographics are not determining mode choice here, though there is a contribution.
Non-motorised Trips

ALL TRIPS

SHOPPING TRIPS

Percent of Total

Year


Public Transit
Auto
Others

100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0

0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0


Public Transit
Auto
Others
Paradox of Infrastructure?

• Japan has a lack of sidewalks and cycling lanes, but has high active travel rates.
• What might explain that?
• Narrow streets → lower speeds.
• Driver behaviour towards non-motorised modes.
• Without designated spaces, cars must pay attention. (Similar to “naked streets”)
CO$_2$, Built Environment, and Household Lifecycle Stage

Photo credit: en.wikipedia.org
GHGs by Built Environment and Household Lifecycle Stage

• Planning to enable reduced GHG through household travel.
• Pre-school and Young school household lifecycle stages make the most trips.
• BE has a stronger impact on modal use, but distances will also vary.
  — What are the energy consumption profiles like?
• How long does each stage last?
• Where should family-oriented dwellings be supported/promoted to reduce GHGs?
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Descriptions</th>
<th>Definitions</th>
<th>Estimated Years at that Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-school nuclear</td>
<td>Nuclear families with pre-school children</td>
<td>Youngest child is five years old or younger</td>
<td>6.6</td>
</tr>
<tr>
<td>Young school nuclear</td>
<td>Nuclear families with young school children</td>
<td>Youngest child 6 or over but under 12</td>
<td>4.4</td>
</tr>
<tr>
<td>Older school nuclear</td>
<td>Nuclear families with older school children</td>
<td>Youngest child 12 or over but under 18</td>
<td>4.5</td>
</tr>
<tr>
<td>All adults</td>
<td>Families of all adults</td>
<td>Nuclear families and single parent families with all members of working age</td>
<td>15.0</td>
</tr>
<tr>
<td>Older childless couple</td>
<td>Older childless-couple household</td>
<td>Oldest person 60 or over</td>
<td>4.1</td>
</tr>
<tr>
<td>Older single</td>
<td>Older single household</td>
<td>Age 60 or over</td>
<td>10.1</td>
</tr>
</tbody>
</table>
# Household daily transportation energy consumption (Kcal/HH)

<table>
<thead>
<tr>
<th>Lifecycle stage</th>
<th>Commercial</th>
<th>Mixed-commercial</th>
<th>Mixed-residential</th>
<th>Autonomous</th>
<th>Developing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-school nuclear</td>
<td>6,999</td>
<td>11,042</td>
<td>21,111</td>
<td>30,837</td>
<td>24,689</td>
</tr>
<tr>
<td>Young school nuclear</td>
<td>8,919</td>
<td>11,703</td>
<td>20,827</td>
<td>29,195</td>
<td>28,598</td>
</tr>
<tr>
<td>Older school nuclear</td>
<td>9,070</td>
<td>15,079</td>
<td>23,551</td>
<td>31,741</td>
<td>30,353</td>
</tr>
<tr>
<td>All adults</td>
<td>9,017</td>
<td>12,722</td>
<td>22,313</td>
<td>32,125</td>
<td>30,846</td>
</tr>
<tr>
<td>Older childless couple</td>
<td>3,610</td>
<td>5,450</td>
<td>10,345</td>
<td>15,362</td>
<td>15,216</td>
</tr>
<tr>
<td>Older single</td>
<td>1,403</td>
<td>1,757</td>
<td>3,173</td>
<td>4,832</td>
<td>6,362</td>
</tr>
</tbody>
</table>
**Per Capita** Transportation CO$_2$ as a % of 2 tonnes (actual tonnage)

<table>
<thead>
<tr>
<th></th>
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<td>34% (0.68)</td>
<td>46% (0.93)</td>
<td>44% (0.88)</td>
</tr>
<tr>
<td>All adults</td>
<td>16% (0.33)</td>
<td>23% (0.45)</td>
<td>39% (0.77)</td>
<td>57% (1.14)</td>
<td>53% (1.06)</td>
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<tr>
<td>Older childless couple</td>
<td>10% (0.2)</td>
<td>15% (0.31)</td>
<td>29% (0.58)</td>
<td>43% (0.87)</td>
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</tr>
<tr>
<td>Older single</td>
<td>8% (0.16)</td>
<td>10% (0.2)</td>
<td>18% (0.36)</td>
<td>27% (0.54)</td>
<td>36% (0.71)</td>
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Under < 33% of Policy Target for 2050

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GHG Summary

• Most urban areas of Osaka Metropolitan Area are currently supporting “sustainable” transportation.

• Younger households appear to be more sustainable.
  – Key difference to North America might be in society’s expectations of household location and children’s travel.
Children in Compact Development

Photo credit: http://news.canpan.info/2012/11/112324.html
“YOU NEED A CAR IF YOU HAVE KIDS”

Are cars really making it easier for parents?
Canadian Parents’ Perceptions

• Sociological study on why Canadian parents generally think it is better/easier to raise children in a rural vs urban setting.

• The rural was thought to be better because:
  – Distances for chauffeuring are shorter;
  – Know neighbours;
  – (combination of the above two allowed for) increased independent travel.
Parents and Children’s Travel

• In the USA, women with children make more trips and drive more miles.
  – Many of those trips are likely serve-passenger.

• In the USA children spent on average 72 minutes/day travelling.

• 65% of all trips were accompanied by an adult.
  – Chauffeuring children may be seen as good parental behaviour.
# Time, Trips, and Chauffeuring

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time spent travelling</td>
<td>72 min.</td>
<td>40 min.</td>
<td>70 min.</td>
</tr>
<tr>
<td>Number of trips</td>
<td>3.52</td>
<td>3.44</td>
<td>3.2</td>
</tr>
<tr>
<td>Trips with parent</td>
<td>65%</td>
<td>15%</td>
<td>67%</td>
</tr>
</tbody>
</table>

- Average time spent travelling with a parent is 4.3 minutes.
- These trips were typically to a store or restaurant – e.g. family-oriented trips.
Children’s Trips⁹ in Osaka Metro Area

- **1970**: 94% Non-motorized, 4% Private motor, 1% Mass transit
- **1980**: 88% Non-motorized, 8% Private motor, 2% Mass transit
- **1990**: 85% Non-motorized, 9% Private motor, 5% Mass transit
- **2000**: 70% Non-motorized, 19% Private motor, 10% Mass transit

Legend:
- **Private motor**
- **Mass transit**
- **Non-motorized**
## Children’s Modal Splits (2000)

<table>
<thead>
<tr>
<th>MODE</th>
<th>5 – 9 YEARS OLD</th>
<th>10 – 14 YEARS OLD</th>
<th>15 – 19 YEARS OLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALK</td>
<td>63%</td>
<td>69%</td>
<td>16%</td>
</tr>
<tr>
<td>BICYCLE</td>
<td>13%</td>
<td>17%</td>
<td>30%</td>
</tr>
<tr>
<td>PUBLIC TRANSPORT</td>
<td>2%</td>
<td>6%</td>
<td>42%</td>
</tr>
<tr>
<td>CAR ETC.</td>
<td>15%</td>
<td>7%</td>
<td>11%</td>
</tr>
</tbody>
</table>
Knowing Neighbours

• Value of knowing neighbours was expressed as:
  – Reduced anxiety through the sense that there is likely someone around who knows their child and could help.
  – The child is also being observed, so is less likely to do foolish things.
Overlaps between Compact Development and (Traditional) Rural Places

- Compact Development
- Less play?
- Strangers?
- Rural
- Distance
- Community Connections
- Open space: place to play

Less play? and Strangers? are overlapping with Distance in both Compact Development and Rural Places.
Previous Work on Traffic and Neighbourhood Connections

• Livable Streets (Donald Appleyard) – social lives vary depending on amount of traffic on street.
• Parents in Canadian study felt that in a rural situation, they knew their neighbours.
  – Very possibly true, but is that an Urban-Rural divide?
• Do children aged 10, 11 in Osaka see people that they know while travelling more often in a rural or urban setting?
## Community Connections

<table>
<thead>
<tr>
<th>Population Density (people/km²)</th>
<th>&lt; 2000</th>
<th>2000 - 4000</th>
<th>4000 - 6500</th>
<th>&gt; 6500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of trips where a known person was seen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekday (N= 265)</td>
<td>64.3%</td>
<td>74.0%</td>
<td>67.7%</td>
<td>78.3%</td>
</tr>
<tr>
<td>Weekend (N=202)</td>
<td>41.7%</td>
<td>42.2%</td>
<td>37.3%</td>
<td>61.3%</td>
</tr>
</tbody>
</table>
Vigorous Play, Mode Use, and Independence

Correlation between mode and vigorous physical activity.

<table>
<thead>
<tr>
<th></th>
<th>Walking</th>
<th>Cycling</th>
<th>By Car</th>
<th>By Bus</th>
<th>By Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekday (N=1607)</td>
<td>0.34**</td>
<td>0.22**</td>
<td>-0.80**</td>
<td>-0.11**</td>
<td>-0.06*</td>
</tr>
<tr>
<td>Sunday (N=1249)</td>
<td>0.38**</td>
<td>0.61**</td>
<td>-0.89**</td>
<td>-0.04</td>
<td>0.05</td>
</tr>
</tbody>
</table>

- When children had physically active activities, they went by their own physical power.
Summary on Compact, Transit-Oriented Development

- Children were more likely to see people that they knew while travelling in more urban areas.
- Children who were physically active, reached those locations by active modes.
Time Use

• Mobility of car allows one to “access” a large number of potential destinations.
  – But does that correspond to people doing more?
• Ryuichi Kitamura compared time use of:
  – Californians (car-based, highly mobile population)
  – Netherlands (more mixed-use, denser development)
## Time Use

<table>
<thead>
<tr>
<th>Activity</th>
<th>California</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep</td>
<td>469.40 (7.82 h)</td>
<td>470.20 (7.83 h)</td>
</tr>
<tr>
<td>Shopping/errands</td>
<td>36.10</td>
<td>34.32</td>
</tr>
<tr>
<td>Personal care</td>
<td>72.16</td>
<td>68.70</td>
</tr>
<tr>
<td>Education</td>
<td>17.77</td>
<td>31.31</td>
</tr>
<tr>
<td>Entertainment</td>
<td>31.23</td>
<td>69.40</td>
</tr>
<tr>
<td>Sports/Hobbies</td>
<td>34.06</td>
<td>54.43</td>
</tr>
<tr>
<td>TV, Reading</td>
<td>225.02</td>
<td>192.34</td>
</tr>
<tr>
<td>Meals</td>
<td>71.58</td>
<td>76.71</td>
</tr>
<tr>
<td>Travel</td>
<td>95.51</td>
<td>68.67</td>
</tr>
</tbody>
</table>
Time Use Summary

• “Slower” modes of travel -> less travel time and more “fun”, socially-engaged activities.
Conclusions

• Hard to imagine for North Americans what life might be like in transit-based & walking based systems.
  – Good to examine other countries.
  – But, social attitudes and values, which can change over time, may differ.

• Many paradoxes exist in contrast to “common knowledge” about travel in North America.
References

References 2


