Cargo Bikes as a Growth Area for Bicycle vs. Auto Trips: Exploring the Potential for Mode Substitution Behavior

ABSTRACT

Cargo bikes are increasing in availability in the United States. While a large body of research has continued to investigate traditional bike transportation, cargo bikes offer the potential to capture trips for those that might otherwise be made by car. To investigate this, data from a survey of cargo bike users are evaluated using descriptive and inferential statistics. The survey queried how use and travel dynamics of characteristics with the hypothesis that cargo bike ownership has the potential to contribute to mode substitution behavior. From a descriptive standpoint, 68.9% of those surveyed changed their travel behavior after purchasing a cargo bike and the number of auto trips appeared to decline by 1-2 trips per day. Two key reasons cited for this change included the ability to get around with children and more gear. This is confirmed by regression models which underscore this trend. Based on these results, further research could include focus on overcoming weather-related / elemental barriers (perhaps with an e-assist capacity), which continue to be an obstacle to every day cycling, and further investigation into families modeling healthy behaviors to children with cargo bikes.

Word Count: 3140
Figures/Tables: 2 / 2 : 1000
Total: 4140

Key Words:
Cargo bikes, Bicycles, Linked Trips, Mode Choice
1. INTRODUCTION
For many years, academics and practitioners have recognized the limitations of bicycling in urban areas (Gallagher, 2010; J. R. Pucher & Buehler, 2012). These include built environment factors (Chatman, 2009; Nuworsoo, Cooper, Cushing, & Jud, P.E., 2012; J. Pucher, Dill, & Handy, 2010a; Saelens, Sallis, & Frank, 2003), weather and topographical conditions (R. Cervero & Duncan, 2003), as well as personal factors (Lawson & Morris, 1999; Lovejoy, Handy, Pucher, & Buehler, 2012; Rosenbloom & Burns, 1993). Increasingly, there has been an emphasis on decisions not to bicycle, which depend less on destination than on personal factors such as stops or links along a trip, transporting children, or the necessity of carrying gear (for oneself or for children.)

This paper posits that the cargo bike platform offers a potential mitigating factor for some these conditions, and can be a tool for mode substitution behavior that draws individuals away from automobiles as their primary mode of travel. The researcher surveys before and after travel behavior of cargo bike owner, exploring trends and significance by using descriptive statistics and linear regression. This data, collected and analyzed, provides for discussion of how this platform might expand urban cycling, especially for those with children.

2. BACKGROUND
A cargo bike is a human powered vehicle / bicycle designed and constructed specifically for transporting loads. Other frequently terms used are freight bicycles, carrier cycles, freight tricycles, box bikes, cycle-trucks or long johns. As depicted in Figure 1, cargo bicycles come in various shapes and sizes, and from a variety of manufacturers. For example, Bakfiets (http://bakfiets.nl/) and Larry vs. Harry (http://www.larryvsharry.com/english/) produce bicycle and tricycle style bikes that can carry a substantive amount of cargo and up to four children. These upright, Dutch-style commute bikes are built with a gender neutral stepover and a front-load carrier. Alternatively, manufacturers such as Yuba Bikes, based in Petaluma, California (http://yubabikes.com/), focus on rear cargo capacity. The Yuba platform is similar those made by other manufacturers that make comparable models, including Kona, Surly, Trek, and XtraCycle.

Figure 1: Examples of cargo bike designs.
Very little literature exists on cargo bikes, specifically; most it focuses more generally on bicycle transportation. For example, an ample body of work deals with bicycles, mode choice and programs to promote cycling (A. R Pinjari, Pendyala, Bhat, & Waddell, 2008; J. Pucher, Buehler, & Seinen, 2011; J. Pucher, Dill, & Handy, 2010b) and the built environment correlates of active transportation (Bors et al., 2009; Dobson & Gilroy, 2009; Frank et al., 2006; S. Handy, Cao, & Mokhtarian, 2005; S. L. Handy, Boarnet, Ewing, & Killingsworth, 2002). Literature shows that young adults and men are more likely to cycle for utilitarian purposes (e.g. trips for errands, to school, or work vs. for leisure) than their older or female counterparts (Winters, Friesen, Koehoorn, & Teschke, 2007).

Some studies analyze the deficiencies and limitations related to these utilitarian trips, especially with regard to carrying gear or children (Akar & Clifton, 2009; R. Cervero & Duncan, 2003; Gallagher, 2010; Heinen, Maat, & van Wee, 2011; Lovejoy et al., 2012). These limitations are especially acute for women who make up a minority of cyclists and are more likely to be responsible for transporting children (Garrard, 2003; Garrard, Handy, & Dill, 2012).

The reference to these limitations, along with other work that has identified the need for the evaluation of different kinds of bike platforms (Blanco et al., 2009), as a research priority indicate the possibility that cargo or utility bikes offer. Such bikes have the potential to provide an opportunity to attract cyclists with utilitarian trip needs. Popular media would tell us that cargo bike use is on the rise (La Ferla, 2010; O’Connor, 2011), and other publications indicate that different forms of bikes could support mode substitution away from autos (Pitaowski--DATE). This is supported by a limited number of publications that offer them as a possible platform to attract a certain demographic user (Shaheen, Guzman, & Zhang, 2010) or for freight, goods movement and logistical purposes (Gruber, Kihm, & Lenz, n.d.; Lenz & Riehle, 2013) – one example being Berlin, which did a trial ban on car courier services within the city center (Gössling, 2013; J. Pucher & Buehler, 2008).

3. METHODS
Given this literature background, the purpose of the study is to learn more about if cargo bikes influence travel differently than standard bicycles, and if they might contribute to mode substitution behavior. This section describes the study data and research framework used.

Study Data
A stated preference survey was used explore the traits of travel before and after the purchase of cargo bikes. The survey was issued via email to database of roughly 2,500 potential and current cargo bike owners. The database was assembled from the mailing lists of two national bike distributors, Cambria Bicycle Outfitters and Yuba Bicycles. The survey complied with all human subjects requirements and was approved by the Cal Poly, San Luis Obispo Committee for the Protection of Human Subjects. All responses were anonymous.

Surveys took approximately 10 minutes to complete and explored three factors: 1) trip mode before and after (auto, transit, traditional bike, cargo bike, walk, other); 2) Trip Type (work, school, other);and 3) individual characteristics and preferences, focusing acutely on trips
involving children. Roughly 300 responses (N=299) were received providing a margin of error of +/-5.6 at the 95% confidence interval.

Modeling Framework
Since this comparative data did not count for interdependence between variables and binomial logistic regression was used to further explore correlation in the data, using specifications consistent with Cervero (2002) and others (Pinjari, Pendyala, Bhat, & Waddell, 2011; Pinjari et al., 2008) including travel time / trip characteristics, trip maker attributes, and built environment attributes. The modeling process involved testing many variables in these categories that have been associated with mode choice. Only variables with the greatest statistical (p < 0.20) significance were kept in subsequent model runs. These are reported in a final model.

4. RESULTS

Descriptive Analysis
On the whole, respondents were white, affluent and well educated: 62% were male. Over 67% had a bachelors or master’s degree. Approximately 50% of respondents made over $100,000 in household income per year, which reflects an upper to middle class income. Most owned 1 or 2 cars. Roughly 50% had two children at home, under the age of six. Another 45% had older children or none at all.

In terms of a baseline for travel characteristics before owning a cargo bike roughly 60% drove alone or with others before they purchased a cargo bike. Most of these trips (68%) were work related (see Figure 2), and 53% of those surveyed dropped off kids on these trips. That said, focusing in on travel after users of a cargo bike mode changed dramatically. As shown in Table 1, 19% reported their car / auto as their primary mode, a 41% reduction in auto trips. (69% respondents used their cargo bike as their primary mode of travel after purchase.) This equates to an over 40% reduction in car use. Compared to prior cargo bike ownership, the number of cargo and traditional bike riders rose from 65 (28.0%) to 154 (79.4%). 133 (68.9%) participants reported that this was a change from how they traveled prior to owning a cargo bike. 60 (31.1%) said that their primary transportation patterns did not change, despite the ownership of a cargo bike, suggesting that many had ridden bikes as their primary means of travel prior to owning a cargo bike.

This is expanded on in Table 2 how which shows the primary utilitarian trips transfer from auto to bike with an inversion of the modal split to 60% of cargo bike riders among cargo bike owners for primary trips. Though some of these trips (roughly 30%) indicate that cargo bikes attract people who are already cyclists, the results indicate that some persons are drawn to automotive modes that increase sustainable forms of human powered mobility. Furthermore, given that each of these trips has multi-links that involve trip chaining, the numbers indicate that a dramatic number of auto trips may be degenerated from local traffic.

The number of auto trips appeared to decline by 1-2 trips for these individuals, and many of these were for trips that total 3-10 miles per day (anecdotally more than average). 62% had considered giving up a vehicle as a result of their cargo bike ownership. Connection between
having kids and cargo bike trips to work suggests that focusing on families with small children (unable to ride a bike) are a key correlation and growth area for bicycle transportation.

**Trip Type**

![Figure 2: Trip Type Before Cargo Bike](image)

**Table 1: Primary Travel Mode Prior to Owning a Cargo Bike**

<table>
<thead>
<tr>
<th>Value</th>
<th>Count</th>
<th>Percent</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car / Truck / Auto</td>
<td>37</td>
<td>19.1%</td>
<td>-40.4%</td>
</tr>
<tr>
<td>Bus / Transit</td>
<td>2</td>
<td>1.0%</td>
<td>-4.6%</td>
</tr>
<tr>
<td>Traditional Bicycle</td>
<td>21</td>
<td>10.8%</td>
<td>-17.2%</td>
</tr>
<tr>
<td>Cargo / Utility Bicycle</td>
<td>133</td>
<td>68.6%</td>
<td>68.6%</td>
</tr>
<tr>
<td>Walking</td>
<td>0</td>
<td>0.0%</td>
<td>-3.9%</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>0.5%</td>
<td>-2.5%</td>
</tr>
</tbody>
</table>
Table 2: Changing modes based on the cargo bike

<table>
<thead>
<tr>
<th>Primary Mode Prior to Cargo Bike</th>
<th>Car / Truck / Auto</th>
<th>%</th>
<th>Bus / Transit</th>
<th>%</th>
<th>Traditional Bicycle</th>
<th>%</th>
<th>Walking</th>
<th>%</th>
<th>Other</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cargo Bike NOT as Primary Mode After Purchase</td>
<td>40.00</td>
<td>66%</td>
<td>2.00</td>
<td>3%</td>
<td>16.00</td>
<td>26%</td>
<td>2.00</td>
<td>3%</td>
<td>1.00</td>
<td>2%</td>
<td>100%</td>
</tr>
<tr>
<td>% of Prior Mode Share</td>
<td>Users NOT Using Cargo Bike as Primary Mode After Purchase</td>
<td>35%</td>
<td>20%</td>
<td>28%</td>
<td>25%</td>
<td>33%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cargo Bike as Primary Mode After Purchase</td>
<td>76.00</td>
<td>57%</td>
<td>8.00</td>
<td>6%</td>
<td>41.00</td>
<td>31%</td>
<td>6.00</td>
<td>5%</td>
<td>2.00</td>
<td>2%</td>
<td>100%</td>
</tr>
<tr>
<td>% of Prior Mode Share</td>
<td>Users Using Cargo Bike as Primary Mode After Purchase</td>
<td>66%</td>
<td>80%</td>
<td>72%</td>
<td>75%</td>
<td>67%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Share (%) after Cargo Bike Purchase</td>
<td>116.00</td>
<td>10.00</td>
<td>57.00</td>
<td>8.00</td>
<td>3.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Primary Mode</td>
<td>60%</td>
<td>5%</td>
<td>29%</td>
<td>4%</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This concept of trip chaining illustrates a key component of the data, that people may be using the bikes for trips that have links, but it should not undermine a more simple point. The majority or respondents — 193 people out of the 299 respondents (65%) — reported changing their primary mode of travel after purchasing a cargo bike. This statistic limits itself to those who had the fiscal and informational means to self-select a cargo bike, nevertheless, the data illustrates the utility and the potential of cargo bikes to influence mode substitution behavior.

Regression Analysis

In this context, when changing the lens to look at the data using a regression framework, this potential for mode substitution crystalizes. As indicated in the best fitting model shown in Table 3, all the signs are as expected based on the hypothesis that cargo bikes can support mode substitution behavior away from autos. Using the shift from car to the cargo bike as the dependent framework, there is a significant negative correlation between those who shifted from using automobiles, transit or traditional bikes. There is also significant positive correlation with kid-related trips, trips other than work or school, and the total number of bike trips.
Table 3: Regression of those who shifted from car to cargo bike

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>After Car / Truck / Auto</td>
<td>-0.465</td>
<td>***</td>
</tr>
<tr>
<td>After Bus / Transit</td>
<td>-0.111</td>
<td>**</td>
</tr>
<tr>
<td>After Traditional Bicycle</td>
<td>-0.349</td>
<td>***</td>
</tr>
<tr>
<td>After Other</td>
<td>-0.079</td>
<td>----</td>
</tr>
<tr>
<td>Drop Kids</td>
<td>0.115</td>
<td>**</td>
</tr>
<tr>
<td>Trip Purpose School</td>
<td>0.017</td>
<td>----</td>
</tr>
<tr>
<td>Trip Purpose Other</td>
<td>-0.093</td>
<td>*</td>
</tr>
<tr>
<td>More Bike Trips</td>
<td>0.262</td>
<td>***</td>
</tr>
</tbody>
</table>

a. Statistical Significance: *** (p<0.05) ** (0.05<p<0.10) * (0.10<p<0.20)
b. Dependent Variable: Shift from Car to Cargo Bike
c. R2 = .33

This would seem to indicate that as an mode substitution tool cargo bikes appear to be pulling individuals I wouldn't of automobiles at the same time of drawing them out of transit and traditional place, resulting in a general drop in automotive trips and increase in bike trips (as indicated by the positive beta value of .262). Based on the higher negative beta values for autos that other modes there appears to be a greater pull to cargo bikes out of automotive modes verses buses or traditional bikes. It is highly likely that many of these trips are related to dropping kids or other trips such as errands or grocery getting. Many of the open ended comments from survey respondents seem to confirm this when respondents provided the following explanation of their trips, rationale, and needs related to the cargo bike platform.

- **Q) Primary Purpose of these trips?**
  - “Errands and child-related activities.”
  - “Picking up/dropping off kids at school.”
- **Q) What is the primary reason you do NOT use your cargo bike?**
  - “Carpooling other children.”
  - “Have an infant too young to be in a bike seat.”
- **Q) What are things you can’t do but would like to on your bike?**
  - “A canopy to protect kids from rain.”
  - “Add another child seat to carry both kids safely.”
  - “Connect my trailer to go shopping, even when I have my children too.”

In general these notes, along with the quantitative data evaluation, reinforce and support the hypothesis that cargo bikes have the potential to be uses as a mode substitution tool away from automotive transportation, and they may be most effective for those with children or who have to
5. CONCLUSIONS
The results of this study indicate an urban sustainability benefit to cargo bike accommodation, since it appears that many who might not otherwise use bicycles would explore the option of cargo bikes as a substitute for an auto. There are many reasons for this decision but there is an especially strong connection between cargo bike use and trips that involve children – a circumstance that has been a challenge for transportation planners for many years (e.g. How do planners and engineers do about trips to drop kids at school? What do you do about all those bags and all that gear?).

This is an important finding since as a newer and more widely adopted bike platform, the cargo bike could provide an opportunity to create a healthy and sustainable commute that can contribute to less auto trips. This has the potential to create a more sustainable, livable and equitable communities and could have a dramatic impact for women – who have traditionally (and stereotypically) been responsible for childcare.

That said, this analysis does have limitations and leave many questions unanswered. Recognizably, studying a population that has self-selected a certain transportation tool, cargo bikes, may limit the external validity and ability to judge the true market applicability. Furthermore, although not much different in price than a mid-range road bike (starting at approximately $1,200), cargo bikes are not cheap, presenting a potential financial obstacle. However, if current popular media is any indication, there is broad market for a new bicycle paradigm where bicycling is ‘chic”, especially among young, urban families (La Ferla, 2010; O’Connor, 2011; J. Pucher & Buehler, 2008). This validates efforts to understand the potential benefit of new paradigms or platforms like cargo bikes.

Put most simply, this study shows potential connections between cargo bikes and shifts away from autos, and if this is the case more work should be done in this area. More work is needed to evaluate how these bike platforms might act as mode substitution tools for those who may not be affluent or have the financial power of choice. Furthermore, how they connect with other modes and impact traffic is worth investigation. In the policy and infrastructure realm, the natural next step might be for local planners and policy makers to explore ways to facilitate and better support cargo bikes (an bikes in general).

For example, some university campuses offer monetary vouchers for individuals seeking to purchase more expensive bikes (Allen, Lipton, & Brooke, 1999; George, Kraschnewski, & Rovniak, 2011; Shoup, 2005; Zieff, Hipp, Eyler, & Kim, 2013). This is a policy that could have applicability on the municipal level. Likewise facilities, as indicated in Figure 3, some urban infrastructure like bike parking and bus racks do not currently support larger bikes. Accommodating such large bike platforms with more spacious bike parking, larger bike boxes, and wider turning radii could ease use of these platforms.
An increase in cargo bikes, which puts more parents with children on the road, will necessitate changes in infrastructure and contiguous safe routes. More bikes on the road may imply safety in numbers, but can also result in more injuries and less safe conditions (Jacobsen, 2003) if the built environment remains unchanged. This requires community action and political decisions that will encourage local governments to reprioritize capital improvement budgets to prioritize bikes. While travelers might face short term increases in traffic patterns, the growth in new platforms, like cargo bikes, will likely have a cumulative impact that will be a catalyst for creation of walkable, bikeable and livable communities in the United States.
6. ACKNOWLEDGMENTS
Omitted in peer review version to protect the identity of the author.
7. REFERENCES


Handy, S., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built

environment affects physical activity. *American Journal of Preventive Medicine, 23*(2S), 64–73.


Jacobsen, P. L. (2003). Safety in numbers: more walkers and bicyclists, safer walking and


Nuworsoo, Ph.D., C., Cooper, E., Cushing, Ph.D., K., & Jud, P.E., E. (2012). *Integration of bicycling and walking facilities into the infrastructure of urban communities* (No. CA-MTI-12-2906). Mineta Transportation Institute. Retrieved from


