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Cargo bikes as a growth area for bicycle vs. auto trips: Exploring the potential for mode substitution behavior

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ABSTRACT

Cargo bikes are increasing in availability in the United States. While a large body of research continues to investigate traditional bike transportation, cargo bikes offer the potential to capture trips for those that might otherwise be made by car. Data from a survey of cargo bike users queried use and travel dynamics with the hypothesis that cargo and e-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, half of the auto travel prior to ownership. Two key reasons cited for this change include the ability to get around with children and more gear. Regression models that underscore this trend toward increased active transport confirm this. Based on these results, further research could include focus on overcoming weather-related/elemental barriers, which continue to be an obstacle to every day cycling, and further investigation into families modeling healthy behaviors to children with cargo bikes.

1. Introduction

For many years, academics and practitioners have recognized the limitations of bicycling in urban areas (Gallagher, 2010; Pucher & Buehler, 2012). These include built environment factors (Chatman, 2009; Nuworsoo, Cooper, Cushing, & Jud, 2012; Pucher, Dill, & Handy, 2010a; Saelens, Sallis, & Frank, 2003), weather and topographical conditions (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 in current research 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 of these conditions, and can be a tool for mode substitution behavior that draws individuals away from automobiles as their primary mode of travel and increases active transportation. To test this, the researcher surveys before and after travel behavior of cargo bike owner, exploring trends and significance by using descriptive statistics and linear regression. This is done to investigate the utility of a unique platform—not to advocate or advertise for the cargo bike as a platform, but to test if it has a utility that might serve travelers in a different way than traditional bicycles, meeting a different set of needs and users. The data from surveys that is analyzed and provides for discussion of how cargo bikes might expand urban cycling—especially for those with children.

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2. Background

A cargo bike is a bicycle designed and constructed specifically for transporting loads. They are frequently named by other terms including freight bicycles, carrier cycles, freight tricycles, box bikes, cycle-trucks or long johns. As depicted in Fig. 1, cargo bicycles come in various shapes and sizes, and from a variety of manufacturers, sometimes with electric assist capacity. For example, some can carry a substantive amount of cargo and multiple children in a front-loading carrier and Dutch-style, gender-neutral step-over, while others focus on rear-cargo capacity. Research has shown that these bike types may have advantages for the transport of gear and children in that they may be more visible, and therefore more safe from collisions, than a pull-behind bicycle trailer (Harris et al., 2011; Lovejoy et al., 2012; Powell & Tanz, 2000).

Despite this opportunity, only a small amount of literature exists on cargo bikes. Specifically, most of the literature has focused more generally on bicycle transportation. For example, an ample body of work deals with bicycles, mode choice and programs to promote cycling (Pinjari, Pendyala, Bhat, & Waddell, 2008; Pucher, Buehler, & Seinen, 2011; Pucher, Dill, & Handy, 2010b) and the built environment correlates of active transportation (Bors et al., 2009; Dobson & Gilroy, 2009; Frank et al., 2006; Handy, Boarnet, Ewing, & Killingsworth, 2002; Handy, Cao, & Mokhtarian, 2005). 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; 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 in the United States, yet are more likely to be responsible for transporting children (Garrard, 2003; Garrard, Handy, & Dill, 2012). This is as opposed to the Netherlands, where use of bikes by women is higher in general (Pucher & Buehler, 2008b). It also may be significant in older populations who may be more inclined to engage in use of e-bikes who may have reduced muscular capacity for riding (Dill & Rose, 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 (Riggs, 2015a). Such bikes have the potential to provide an opportunity to attract cyclists with utilitarian trip needs. Some sources suggest that cargo bike use is on the rise (La Ferla, 2010; O'Connor, 2011), and other publications indicate that different formats or types of bikes have the potential to support mode substitution away from autos (Piatkowski, Krizek, & Handy, 2015).

This idea of the mode substitution behavior potential of cargo bikes is propped up by a small number of publications that offer cargo bikes as a possible type of human-powered transport that can attract a certain demographic user (Shaheen, Guzman, & Zhang, 2010), or that can be used for freight, goods movement and logistical purposes (Gruber, Kihm, & Lenz, n.d.; Lenz & Riehle, 2013). One study cites the example of Berlin, which did a ban on car-courier services within the city center in favor of cargo bikes (Gössling, 2013; Pucher & Buehler, 2008a). These cargo bike focused studies are also paralleled by recent work which suggests that mode choice and travel behavior is not based solely on origin-destination or financial market factors, but also on social, behavioral and cultural norms (Carrel, Ekambaram, Gaker, Sengupta, & Walker, 2012; Riggs, 2015b; Riggs & Kuo, 2014; Riggs & Kuo, 2015).

3. Methodology

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.

3.1. Study data

A stated preference survey was used to explore the traits of travel before and after the purchase of a cargo bike. The goal of the survey was to explore those who had self-selected this modal platform and how it influenced their travel choices after

Fig. 1. Examples of varying cargo bike designs.

their purchase. The survey was issued to an email list of roughly 2500 individuals who had recently purchased a cargo bike. Yuba Bicycles, a leading vendor of cargo bikes in the US, provided the list through a relationship facilitated by a California-based vendor, Cambria Bicycle Outfitters. While this was a potential limitation of the study in that it focused primarily on one particular manufacturer, it had a few advantages in the study of use and mode substitution behavior: (1) they only manufacture cargo bikes that are distributed both in the US and internationally; (2) they offer numerous cargo bike platforms for buyers to choose from (e.g. rear, electric, front-loading, small); and (3) they offer a product that is more cost-effective than other manufacturers, helping address potential limitations of cost (i.e. concerns that only the affluent can afford a cargo bike).

Surveys took approximately 10 min to complete and explored three factors: (1) trip mode before and after the purchase of a cargo bike (e.g. 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 were received, 194 of which were ruled as valid ($N = 194$) providing a margin of error of ±7 at the 95% confidence interval. 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.

3.2. Modeling framework

To begin the modeling process a robust descriptive analysis was conducted using crosstabs and evaluating change over time. Secondly, since this comparative data did not account for interdependence between variables, binomial logistic regression was used to further explore correlation in the data, using specifications consistent with Cervero (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 had been associated with mode choice. Only variables with the greatest statistical ($p < 0.20$) significance were kept in subsequent model runs. These were reported in a final model.

4. Results

4.1. 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 a middle to upper class income. Most owned 1 or 2 cars. Roughly 50% had two children at home, under the age of six. Another 45% had either one child or older children. This meant that 95% of those who has purchased a cargo bike had children, and while this factor might indicate some degree of self-selection bias, it does illustrate a key point—that parents are the dominant purchasers of these bicycle types. The connection between having kids and cargo bike trips suggests that focusing on families with small children (unable to ride a bike) may be a key growth area for bicycle transportation.

In terms of travel characteristics, as shown in Table 1, before owning a cargo bike roughly 60% of respondents drove alone or carpooled before they purchased a cargo bike. Most of these trips (68%) were work-related (see Fig. 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. Again, referencing Table 1 and 19% reported their car/auto as their primary mode after purchasing a cargo bike, a 41% reduction in auto trips/car use. 69% of respondents used their cargo bike as their primary mode of travel after purchase. Also of note, the cumulative amount of cycling rose after purchase of a cargo bike. The total number of cargo and traditional bike riders rose from 57 (29.4%) to 154 bike riders in total (79.4%).

133 participants (68.9%) reported that this was a change from how they traveled prior to owning a cargo bike. 60 participants (31.1%) said that their primary transportation patterns did not change, despite the ownership of a cargo bike. This likely relates to the fact that some had ridden bikes as their primary means of travel prior to owning a cargo bike, illustrated in Table 2. Table 2 shows the trips that changed 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 people are drawn away from automotive modes, increasing sustainable forms of human powered mobility.

Table 1
Primary travel mode before and after owning a cargo bike ($N = 194$).

Value	Count before	Percent before (%)	Count after	Percent after (%)	Percent change (%)
Car/Truck/Auto	116	59.8	37	19.1	−40.7
Bus/Transit	10	5.2	2	1.0	−4.1
Traditional bicycle	57	29.4	21	10.8	−18.6
Cargo/Utility Bicycle	NA	NA	133	68.6	68.6
Walking	8	4.1	0	0.0	−4.1
Other	3	1.5	1	0.5	−1.0

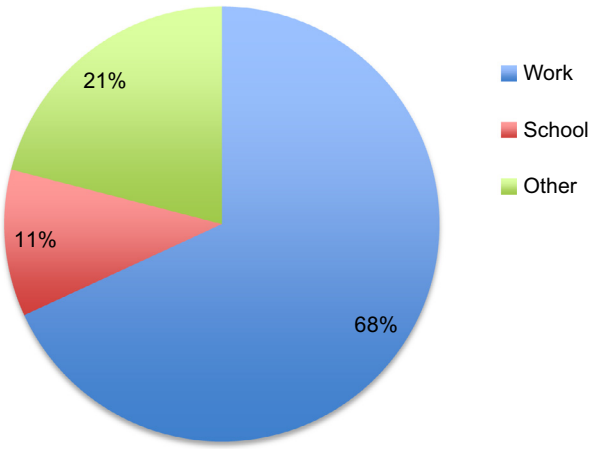

Fig. 2. Trip type before owning a cargo bike.

In total, the number of auto trips appeared to decline by 1–2 trips for these individuals. While they had been making between 5 and 6 auto trips per day this was reduced to 3 or 4. Many of these were for trips that total 3–10 miles per day (anecdotally more than average). Given that each of these trips likely has multiple links and involve trip chaining, these figures may help understand the exact number of auto trips degenerated from local traffic by cargo bikes. Results indicated that 62% had considered giving up a vehicle as a result of their cargo bike ownership, although it is unclear whether or not they did in-then-end give up that vehicle.

The aforementioned notion of trip chaining illustrates a key component of the data: that people may be using the bikes for trips that have links. It should not, however, undermine a more simple point. A majority of respondents who had been drivers (66%) reported changing their primary mode of travel to cycling after purchasing a cargo bike. This statistic may be limited to those who had the financial 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.

4.2. Regression analysis

When changing the lens to look at the data using a regression framework, the potential for mode substitution behavior from cargo bikes crystalizes. As indicated in the best fitting model shown in Table 3, all the signs are as expected when evaluating the modal shift for individuals who changed from driving to riding a cargo bike ($N = 133$). Using the shift from a car to the cargo bike as the dependent framework, there is a significant negative correlation between those who shifted from using automobiles ('After Car/Truck/Auto'), transit ('After Bus/Transit') or traditional bikes ('After Traditional Bicycle'). There is also significant positive correlation with kid-related trips ('Drop Kids'), trips other than work or school ('Trip Purpose Other'), and the total number of bike trips ('More Bike Trips'). This supports the hypothesis that cargo bikes can support mode substitution behavior away from autos.

The regression framework also illustrate what appear to be limitations of the cargo bikes as a mode substitution tool in that they sometimes target those who would otherwise walk, ride a traditional bike or take transit. The regression seems to indicate that as a mode substitution tool cargo bikes appear to be pulling individuals out of automobiles ('After Car/Truck/Auto') in addition to transit ('After Bus/Transit') and traditional bikes ('After Traditional Bicycle'), resulting in a general drop in automotive trips and increase in total bike trips of all kinds (as indicated by the positive beta value of .262 in 'More Bike

Table 2
Mode prior to owning a cargo bike.

	Primary mode before owning a cargo bike										
	Car/ truck/ auto	%	Bus/transit	%	Traditional bicycle	%	Walking	%	Other	%	Total
Number not using cargo bike as primary mode after owning	40.00	66	2.00	3	16.00	26	2.00	3	1.00	2	100
% Not using cargo bike as primary mode after owning	35		20		28		25		33		
Number using a cargo bike as primary mode after owning	76.00	57	8.00	6	41.00	31	6.00	5	2.00	2	100
% Using cargo bike as primary mode after owning	66		80		72		75		67		
Total	116.00		10.00		57.00		8.00		3.00		
Total% after cargo bike purchase	60		5		29		4		2		

Table 3
Regression of those who shifted from car to cargo bike (N = 133).

	B	Sig.
(Constant)		***
After car/truck/auto	−0.465	***
After bus/transit	−0.111	**
After traditional bicycle	−0.349	***
After other	−0.079	–
Drop kids	0.115	**
Trip purpose school	0.017	–
Trip purpose other	−0.093	*
More bike trips	0.262	***

[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.

Trips'). That said, based on the higher negative beta values for 'After Car/Truck/Auto' than other modes, cargo bikes appear to have a greater pull out of automotive modes than buses or traditional bikes, as indicated by the 'After Bus/Transit' and 'After Traditional Bicycle' variables.

It is highly likely that many of these trips are related to dropping kids or other trips such as errands or grocery getting, however, trips to school, 'Trip Purpose School', was not significant factor in the regression. This area of school-based trips is one that may be fertile for future research and investigation as many of the open-ended comments from survey respondents seem to confirm this idea. When respondents provided qualitative explanation of their trips, their rationale for using or not using a cargo bike, and their needs related to their bike they would make statements like those articulated below.

(Q) Primary Purpose of these trips?
- o "Errands and child-related activities."
- o "Picking up/dropping off kids at school."

(Q) What is the primary reason you do NOT use your cargo bike?
- o "Carpooling other children."
- o "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?
- o "A canopy to protect kids from rain."
- o "Add another child seat to carry both kids safely."
- o "Connect my trailer to go shopping, even when I have my children too."

In general, these notes and the quantitative data evaluation, reinforce and support the hypothesis that cargo bikes have the potential to be used as a mode substitution tool away from automotive transportation, and they may be most effective for those with children or who have to carry loads.

5. Conclusions

The results of this study indicate an urban sustainability benefit to cargo bike accommodation. 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 likely many reasons for this decision, but this research shows that 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 practical and theoretical 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. On a practical level this finding provides insights into new platforms that could encourage less driving and sustainable behavior. This could have a dramatic impact for women, who have traditionally (and stereotypically) been responsible for childcare (Garrard, 2003; Garrard, Rose, & Lo, 2008). The cargo bike may offer a tool for commuting without a car, with multiple children, and a significant amount of gear. This station-wagon-effect is an important factor stemming from this work, and one that needs more research, especially given that there are likely many thoughts that go into parental mode choice other than traditional origin-destination travel models.

This notion of mode choice as it relates to traditional origin and destination models also has ties to the theoretical implications of this work. Similar to other research that has suggested the effectiveness of activity based travel modeling (Ben-Akiva & Bowman, 1998; Bowman & Ben-Akiva, 1997), this study suggests that travel mode choices are complex (Brock & Durlauf, 2003; Cirillo & Axhausen, 2002), and many times affected by factors other than distance, time, and even weather. As this work shows, simply having a child along for a ride on a non-school-based trip can be connected to driving—or in idealized case of our respondents, driving a cargo bike. This would seem to indicate that modal choices should be seen

as dynamic, everyday occurrences, and that interventions that make travel by bike less of an obstacle (like a having a cargo bike to haul children or goods) and also align with behavioral or cultural norms (e.g. environmental or cultural beliefs) can make a difference in travel decisions.

That said, this study does have limitations and leave questions unanswered. Recognizably, studying a population that has self-selected a certain transportation tool, cargo bikes, may limit the external validity. It may be that those who elect to own a cargo bike are already inclined to bike, or already have social-cultural beliefs associated with sustainable commuting and biking. That said, this may be a moot point in that 68% of those who were surveyed switched from driving to riding a cargo bike for between 1 and 2 of their daily trips, indicating that they may be facing obstacles to their desired mode (cycling) on a regular basis. Furthermore, as mentioned previously, a possible limitation could be cost. Although not much different in price than a mid-range road bike (starting at between $1200 and $1500), many cargo bikes are not as cheap as a traditional bike. This price-point could present a socio-economic limitation, although there are indications that these prices do appear to be declining. (La Ferla, 2010; O'Connor, 2011; Pucher & Buehler, 2008a). Furthermore, some might argue that this presents an opportunity for individuals to buy used bikes on the pre-owned market. In the Netherlands a variety of bikes, including cargo bikes are offered second hand at more affordable prices on Marktplaats (http://www.marktplaats.nl/). Likewise in the US, many bikes can now be purchased in the $500-range on eBay and Craigslist.

In review, 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 research is needed to evaluate how these bike types connect with other modes, impact traffic, need specific infrastructure and might be made available more widely, especially for those who may not normally be able to afford them.

With regard to the latter two, infrastructure and affordability, the natural next step might be for local planners and policy makers to explore ways to facilitate and better support cargo bikes. For example, relating to the affordability of these platforms, some university campuses have begun to 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 done as a transportation demand management effort to incentivize cycling over driving and parking at a substantial savings to the institution (Tudela-Rivadeneyra, Shirgaokar, Deakin, & Riggs, 2015). A policy that provided bike vouchers for cargo bikes could be applied on the municipal level and be an efficient alternative to providing parking spaces. It could increase the number of cargo bikes on the road for families, while at the same time reducing the burden of providing expensive parking infrastructure (Riggs, 2014).

Likewise, as indicated in Fig. 3, facilities and some urban infrastructure like bike parking and bus racks do not currently support cargo bikes, larger bikes or trailers. On a practical level this poses an issue to bikes as well as pedestrians where space needs to be made for both transportation modes. Accommodating the cargo bike platform with more spacious bike parking, larger bike boxes, and wider turning radii could ease use of these kind of bikes, while providing the necessary clearance for pedestrians to navigate the areas near bike parking.

Put most simply, the built environment must continue to change in the US to accommodate more bicycles—including cargo bikes. And while the market for cargo bikes might represent a small segment of all travelers, this research indicated that it does have the potential to put more parents with children on the road—an additional justification for changes in infrastructure and contiguous safe cycling routes. More bikes of all types on the road may imply safety in numbers, but can also result in more injuries and less safe conditions if the built environment remains unchanged (Jacobsen, 2003). This requires community action and political decisions that will encourage local governments to reprioritize capital improvement budgets to prioritize bicycle infrastructure for all types of cyclists. And in sum, with any luck the cumulative impacts of all bike types will be a catalyst for the creation of more walkable, bikable and livable urban areas.

Fig. 3. A cargo bike parked at a bike rack, blocking the sidewalk.

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