



# Sustainable transportation infrastructure investments and mode share changes: A 20-year background of Boulder, Colorado



Alejandro Henao<sup>a,\*</sup>, Daniel Piatkowski<sup>b</sup>, Kara S. Luckey<sup>b</sup>, Krista Nordback<sup>a,1</sup>, Wesley E. Marshall<sup>a</sup>, Kevin J. Krizek<sup>b,2</sup>

<sup>a</sup> Department of Civil Engineering, University of Colorado Denver, P.O. Box 173364, Campus Box 113, Denver, CO 80217-3364, USA

<sup>b</sup> College of Architecture and Planning, University of Colorado Denver, P.O. Box 173364, Campus Box 126, Denver, CO 80217-3364, USA

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## ABSTRACT

This case study examines transportation infrastructure investments along with data revealing mode share in order to highlight correlations between investments in sustainable transportation infrastructure ('supply') and patterns of non-automobile mode share ('demand'). The analysis assesses data from Boulder, Colorado, a city that has made substantial efforts to improve its multi-modal transportation infrastructure and services by investing in pedestrian, bicycle, and transit infrastructure and services. We aim to describe connections between supply and demand by measuring two phenomena: the extent of transportation infrastructure investments supporting pedestrian, bicycle, and transit modes made between 1990 and 2009 and the share of these modes during the same 20 years period. Results illustrate an overall increase in transit and bicycle mode share and a decrease in single occupancy vehicle share, with consistent pedestrian share. We conclude that Boulder's investments in improving mode choices through new infrastructure and services supporting non-automobile modes are associated with increasing share of non-automobile modes. This is despite national trends that indicate an increasing automobile mode share. Regardless of the reasons for the positive trends experienced in Boulder, the presence of robust pedestrian, bicycling, and transit infrastructure has clearly coincided with evolving travel preferences. Boulder therefore serves as an example for other cities desiring to focus on developing policies and infrastructure that expand the availability of non-automobile modes.

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## 1. Introduction

Communities across the United States (US) are increasingly promoting walking, cycling, and transit as sustainable modes of transportation in an effort to achieve a wide range of benefits including reduced congestion, lower levels of air pollution, decreased fuel dependency, and improvements to human health. Such outcomes, however, require substantial shifts away from auto-dependence, which few cities in the US have achieved. Boulder, Colorado is one of the few cities (along with other outliers

\* Corresponding author. Fax: +1 303 556 2368.

E-mail addresses: [alejandro.henao@ucdenver.edu](mailto:alejandro.henao@ucdenver.edu) (A. Henao),

[daniel.piatkowski@ucdenver.edu](mailto:daniel.piatkowski@ucdenver.edu) (D. Piatkowski),

[kara.luckey@ucdenver.edu](mailto:kara.luckey@ucdenver.edu) (K.S. Luckey),

[krista.nordback@ucdenver.edu](mailto:krista.nordback@ucdenver.edu) (K. Nordback),

[wesley.marshall@ucdenver.edu](mailto:wesley.marshall@ucdenver.edu) (W.E. Marshall), [krizek@colorado.edu](mailto:krizek@colorado.edu) (K.J. Krizek).

<sup>1</sup> Present address: Oregon Transportation Research and Education Consortium Portland State University, P.O. Box 751, Portland, OR 97207, USA.

<sup>2</sup> Present address: University of Colorado, Boulder, Program in Environmental Design 1060 18<sup>th</sup> Street, Boulder, CO 80309-0314, USA.

such as Portland, Oregon; Davis, California and Cambridge, Massachusetts) that has invested heavily in sustainable transportation infrastructure over recent decades and simultaneously experienced increased share of these modes. The city has been recognized as a "Platinum" bicycle-friendly community (League of American Bicyclists, 2012) and boasts an extensive local and regional transit system. Interestingly, travel behavior in Boulder did not differ appreciably from neighboring communities as recently as the early 1980s (Pedestrian and Bicycling Information Center, 2012), but a series of policy decisions and infrastructure investments over the past 30 years have coincided with Boulder's rise to outlier status among US cities for non-auto travel (Krizek and Langegger, 2009).

This paper systematically reviews transportation investments made between 1990 and 2009 in Boulder along with data on mode share in order to highlight correlations between investments in sustainable transportation infrastructure and increased use of these modes. The study first examines funding allocated to pedestrian, bicycle, and transit infrastructure, and then evaluates changes in mode share for pedestrian, bicycling, transit, and single

occupancy vehicle (SOV) modes using data from multiple local and national sources. We hypothesize that there will be evidence of increased pedestrian, bicycling, and transit use (i.e. mode share) while SOV mode share decreases. We do not attempt to identify causal relationships; rather, we expect to observe a pattern in which infrastructure investments over the last twenty years are associated with increased rates of non-auto travel. Indeed, results support this hypothesis: we find that Boulder invested heavily in the “supply” of non-auto infrastructure while simultaneously experiencing an increase in “demand” as measured by the mode share of non-auto modes. We conclude by comparing mode shifts in Boulder to national trends and identifying informed recommendations for communities looking to invest in sustainable transportation.

### 1.1. Background

Benchmarking and evaluating investments in sustainable transportation is critical for cities interested in promoting these modes, but available data is sparse (Alliance for Walking and Biking, 2010). Consequently, academic literature evaluating such investments is even sparser. Another reason for the existence of few studies is the difficulty of examining trends over time with respect to municipal transportation investments and travel behavior (Krizek et al., 2009). For example, how does one control for complementary land use development resulting from initial transportation investments? Challenges associated with confounding factors make establishing causality extremely difficult (Krizek et al., 2009). The literature points out that these potential pitfalls are common when the timespan examined is 10 years or less but can be reduced by investigating longer periods of time (Dueker and Bianco, 1999; Ratner and Goetz, 2013). Drawing upon a unique dataset that provides supply and demand side data over twenty years, our analysis of Boulder, Colorado offers insights into long-term outcomes associated with sustainable transportation investments.

This paper presents a methodologically-novel investigation of the relationship between investments (in terms of city transportation budget allocations) and mode share. Existing literature tends to focus on investments in mode-specific infrastructure, or alternately, considers the impacts of transportation investments in predictive scenario-analyses. Investments in city-scale bicycling infrastructure (Krizek et al., 2009) and the implementation of light rail systems (Dueker and Bianco, 1999; Bhattacharjee and Goetz, 2012) have each been analyzed using a “case study” approach to assess the investment’s impact on a variety of outcome measures. There is even a case study paper that considers the differing mode share impacts of a city that invested heavily in limited access highways and off-street parking as compared to one that did not (McCahill and Garrick, 2010). However, we are not aware of any studies that consider walking, bicycling, and transit – and their respective investments – simultaneously.

‘Supply’ measures in these existing case study papers tends to focus on physical infrastructure (e.g., miles of rail lines or bicycle lanes), rather than investment dollars, which is the focus of this paper. On the other hand, ‘demand’ measures tend to focus on mode share shifts in all cases. Examples of studies utilizing comparable supply and demand measures similar to this study are largely limited to cost-benefit analyses of proposed investments in sustainable transportation. Cavill et al. (2008) provides a review of economic analyses of transportation infrastructure and policies on health. Gotschi (2011) present a more recent approach measuring the economic impacts of bicycle investments on health outcomes. Other studies have considered the future impacts of transportation policies on energy use and carbon emissions (Poudenx, 2008). Investments in specific modes, such as bus rapid transit, have also

been examined for possible impacts on carbon emissions (Hook et al., 2010) and land development (Rodríguez and Targa, 2004). Taken together, the existing literature underscores the need for research into the relationship between investments in sustainable transportation and travel behavior outcomes at the city-scale.

### 1.2. Case study selection

Boulder, Colorado, a city of just over 100,000 people, is located approximately 30 miles northwest of Denver at the foothills of the Rocky Mountains. Boulder is home to the University of Colorado, whose 30,000 students swell the city’s population during the academic year. Boulder is an ideal case study because it represents a “pilot case” (Yin, 2009) or “atypical case” (Flyvbjerg, 2006) with its high levels of investment in sustainable transportation modes and extensive data collection efforts, thus providing maximum information on promoting sustainable transportation through budgetary investments. The city meets three important criteria needed for this investigation: (i) the city has invested heavily in infrastructure supporting non-auto modes; (ii) data on mode share and investments over time are widely available and (iii) Boulder has been recognized nationally for their multi-modal transportation system. Until the recent past, Boulder has a history of being relatively auto-dependent, making its experience generalizable to other auto-oriented cities over the long-term.

Over the years, Boulder has made significant investments in the multi-modal network. The city is now well known for its grade-separated bicycle and pedestrian paths, which are integrated into a network of bicycle lanes, cycle-tracks, and on-street bicycle routes. Boulder also provides an innovative community transit network that connects downtown, the University of Colorado campuses, and local shopping amenities. While the city has no rail transit, local and regional shuttle busses are funded by a variety of sources and emphasize minimal headways, enhanced route identity, easy fare payment, and community input in design (RTD, 2005). Due in part to these investments in pedestrian, bicycle, and transit infrastructure, Boulder has been recognized both nationally and internationally for its transportation system. In 2005, the city won the “Best Workplaces for Commuters District” award from the International Downtown Association for its innovative downtown employee Eco Pass Program, which encourages transit use (City of Boulder, 2011b). In 2009, the Federal Highway Administration recognized Boulder as an “Exemplary Human Environment Initiative” for one of its multi-modal redevelopment projects (City of Boulder, 2008). The city is also one of the first three cities to receive the League of American Bicyclists’ “Platinum Bicycle Friendly Community Award” (League of American Bicyclists, 2012). Numerous additional accolades recognize the city’s unique efforts to promote multi-modal travel (City of Boulder, 2011b).

In addition to being the home of a large institution of higher education, Boulder is also a regional population and employment center situated on the western edge of Colorado’s Rocky Mountain Front Range region, a 40-mile wide by 200-mile long area that is home to about 80-percent of the state’s population. The Denver–Boulder metropolitan area accounts for approximately two-thirds of the regional, Front Range population.

Between 1990 and 2000, Colorado registered the third fastest state growth rate (Ingram et al., 2009), and between 2000 and 2010, Colorado ranked ninth with a 19-percent growth rate (U.S. Census Bureau, 2011b). Unlike the rest of Colorado, Boulder has limited its growth geographically through its own version of an urban growth boundary and internally through zoning control (Krizek and Langegger, 2009; Talucci 2011). While Boulder’s population growth rate has been limited to less than one-percent per year, higher growth rates in surrounding communities have shaped regional travel patterns. For example, the population of

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