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Jobs/housing balance and employer-based travel demand management program returns to scale: Evidence from Los Angeles

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ABSTRACT

Research on environmental justice and social inclusion suggests that high-income wage earners may have better job access due to their greater choices in both housing and transportation markets. This study compares the jobs/housing balance and mode choice of different groups of employees of a large employer (27,113 employees) and those of the "reference groups" from comparable employees working for smaller employers in Los Angeles. Based on spatial and statistical analyses, this paper finds the following:

a) Across all employee groups, a better jobs/housing balance was accompanied by higher income, as was likelihood to patronize Travel Demand Management (TDM) programs.
b) Employees from the large employer had more options for carpooling and thus drove alone less, even after controlling overall housing stock, residential location, annual income, and/or commute time.
c) Across all employee groups, good jobs/housing balance did not necessarily bring about green mode choice.
d) Comprehensive TDM measures by the large employer significantly reduced employees' dependence on driving, even in a region where autocommuting dominates. However, these measures were costly to implement.
e) Different employee groups favor different TDM programs, and the patterns are marked by income.

The above findings suggest that shared or consolidated TDM and housing programs, which pool smaller employers, might better promote green mode choice. Participating employers may also negotiate better deals for program implementation when these programs involve third-party transit agencies and contractors.

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1. Introduction

For decades, planners, researchers and policymakers have viewed jobs/housing balance as an important means to reduce auto commuting (Giuliano, 1991; Pollard, 2007). Jobs/housing balance describes the geographic distribution of both residential and employment opportunities within metropolitan regions. If workers live far (in either space or time) from opportunities, that situation suggests an imbalance. Indicators that people often use to measure the severity of this problem include average commute time/distance, mode split (especially rate of drive-alone or rate of alternative modes to drive-alone), and job or housing access by social group.

Jobs/housing matters to commuting and urban form in several different dimensions. First, jobs/housing imbalance can lead to longer commutes overall, including what some have described as "wasteful" commuting (Buliung and Kanaroglou, 2002; Frost et al., 1998; Horner and Murray, 2002; Kim, 1995; Merriman et al., 1995; Rodriguez, 2004). Second, jobs/housing imbalance reinforces the dominance of solo-driving trips (Asmervik and Naess, 1995; Cervero, 1998; Dieleman et al., 2002; Giuliano, 1991; Scott et al., 1997; Smart Growth America, 2003). Third, jobs/housing imbalance can create barriers to employment for workers or job-seekers who do not have a car (Blumenberg and Ong, 2001; Ong and Blumenberg, 1998). These three issues—longer commutes, single-occupant commuting, and social exclusion—are related to secondary phenomena, such as traffic congestion and deteriorating air quality, and thus, many authors

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studied jobs/housing because they wanted to address these related social and environmental problems (Giuliano, 1991).

Existing studies examined the jobs/housing balance at different geographical levels. For instance, at the national level, the general trend of journeys to work in the U.S. has been explored (Pucher and Renne, 2003). At the metropolitan level, authors have looked into the excess commute issue based on jobs/housing choice and/or commutes of particular groups (Buliung and Kanaroglou, 2002; Frost et al., 1998; Kim, 1995; Merriman et al., 1995; Rodriguez, 2004). At the intra-metropolitan level, Giuliano and Small (1991) identified multiple employment centers in Los Angeles and compared the commutes of workers from these centers and elsewhere in the region. At the employer (workplace) level, Wachs et al. (1993) conducted a longitudinal analysis of commutes of 30,000 employees at Kaiser Permanente (Kaiser), one of the largest employers in Southern California. Except Wachs et al. (1993), all other authors focused on employees' jobs/housing balance and commutes across employers.[1]

This study, by contrast, contributes new information about the role that employers play in shaping their employees' housing and commute choices. Without research on jobs/housing balance that considers employer characteristics, it would be difficult for us to understand how employer-based actions or programs contribute to the balance and green transportation mode choice.

Specifically, looking at specific employers allows us to answer important questions such as

a) how does the jobs/housing balance picture look like for employees at different income levels, after controlling employer and/or workplace?
b) would employer-specific Travel Demand Management (TDM) measures such as subsidized bus fares, a sponsored vanpool program, and discounted carpool parking fees significantly affect employees' mode choice, ridesharing behaviors, jobs/housing balance?
c) if TDM measures are effective with a specific employer, are they transferrable to other employers?

These are the questions that we address in this manuscript/study using data from the University of California, Los Angeles (UCLA), the Los Angeles region's fourth largest employer.

This manuscript is organized into six sections. The next section, Section 2, covers the relevant literature. Section 3 describes the data used in this study and compares the residential patterns and commutes of UCLA employees and those of other employers. Section 4 introduces the TDM measures implemented at UCLA and discusses how these measures affected transportation mode or housing choices of UCLA employees in light of the patterns disclosed in Section 3. Section 5 explores the costs of implementing TDM measures at UCLA so as to demonstrate how expensive it would be for other employers to emulate these measures. Section 6 concludes and discusses possible future improvements to relevant analyses.

2. Relevant literature

Employer-based studies of commuting are rare because there are few publicly available data sources on employees by employer. Public agencies such as the U.S. Census and Metropolitan Planning Organizations (MPOs) do not always have publicly available employment and residential data relevant to housing location or transportation mode choice for employees going to the same location. For instance, the U.S. Census' Transportation Planning Packages (CTPPs) provide only residence and employment counts by Traffic Analysis Zone (TAZ) and do not differentiate employment and residences by employer. The recently launched Longitudinal Employer-Household Dynamics (LEHD) dataset by the U.S. Census reports residential data about employees working in geographical areas such as cities and zip codes. But again, employees are not differentiated by employer. Similarly, in cases where MPOs collect or assemble their own residential and employment data, most are at the TAZ level. Data collected by individual employers, even those reported to MPOs, are often shared only among member agencies and hired consultants (Johnston, 2004).

A few studies have been published, and those have used proprietary data. Wachs et al. (1993) studied the work trips of 30,000 employees working for Kaiser in Southern California over 6 years. Based on these data, the researchers found that the work trip lengths were in general stable and that the automobile was the favored commute mode. Kaiser employees related that they weighed many factors in their residential location decisions, such as distance to workplace, the quality of neighborhood, schools, and perceived safety.

Despite how few studies have been done, employers such as universities have made wide-ranging commitments to sustainable transportation for their workplaces. As of July 2010, 673 universities and colleges had signed the American College and University Presidents' Climate Commitment (ACUPCC) designed in part to promote sustainable transportation. University employers appear to understand that many university employees, especially faculty members, may have greater flexibility to stagger their hours or telecommute, and thus universities may have a better opportunity to experiment with, evaluate, and showcase more sustainable transportation options than other large employers (Toor and Havlick, 2004).

A recent review of university-based TDM programs suggests that such optimism may be warranted (Victoria Transport Policy Institute, 2010). Based on a study of travel behaviors of the UCLA employees and students before and after the implementation of a TDM program called BruinGO, for instance, researchers found that employees' percentage of commuting by public transit increased by 11% and commuting by solo driving decreased by 4% for those living inside the BruinGO bus service area. BruinGO provided fare-free rides for all UCLA employees who worked at least 49% of time and students who registered at least eight credit hours per semester (Brown et al., 2003). In an earlier study of the U-Pass program at the University of Washington (UW), Seattle, the author reported that the UW faculty and staff's drive-alone rate decreased by 3–4% and public transit share increased by 7–9% after the program was implemented (The Transportation Office, 1997). Similar to BruinGO, U-Pass enabled UW employees to take public transit at a discounted price.

Some factors might limit the reach of the university-based TDM measures. These factors include local housing cost, the supply of fast and convenient alternative modes, the need to transport children and chain other types of trips, the need for a vehicle at work, and employee income (Shannon et al., 2006; Toor and Havlick, 2004). Shannon et al. (2006) studied mode choice, primarily to promote active transportation, walking and biking, among students and employees. Travel time was found to be the most important factor when promoting biking and walking, which suggests that jobs/housing balance is important to reducing commute distance and active modes. As a whole, the existing literature, efforts, plans, and case studies suggest that employers, and particularly large employers like universities, can influence housing and mode choices.

[1] (Buliung and Kanaroglou, 2002; Cropper and Gordon, 1993; DeSalvo and Huq, 1996; Frost et al., 1998; Giuliano, 1991; Giuliano, 1995; Gordon et al., 1986; Hamburg et al., 1963; Hanson and Pratt, 1988; Horner and Murray, 2002; Kawabata, 2005; Kim, 1995; Levine, 1998; McCarthy, 1980; Merriman et al., 1995; Small and Song, 1992; Rodriguez, 2004).

Case studies can help enlighten how employer-based TDM measures can make a difference in terms of promoting a better jobs/housing balance and alternative modes to drive-alone. It is to the second set of UCLA experiments with TDM we now turn.

3. Data

This study used multiple data sources, combining employee identifiers and geospatial information.

3.1. Employee socio-demographic and commuting information

There are two different but overlapping sources of data used in this study. First, an employee database was used to geocode the residences and to calculate journey-to-work travel times of all full-time UCLA employees residing in Los Angeles County. This database had 27,113 records; 250 of them were not used because they contained missing information or used a post office box to replace the residential address. For reasons of confidentiality, the data retrieved were only a collection of unique encoded employee identification numbers (EEID), gender, age group, home address, income band, and job classification (faculty versus staff). But even so, the data had provided more details about individual employees than the U.S. Census data mentioned above.

A second database was created based on the results from the 2006 South Coast Air Quality Management District (SCAQMD) survey conducted at UCLA. In this annual transportation survey, university employees indicated their primary mode of travel to the university during a designated one-week period (typically in March). The survey collected information on the primary commute mode and whether the respondent stayed home, telecommuted, or used a compressed work week day. The survey was based on a 10% sample of the university's employees, and it had, for regulatory reasons, at least a 90% response rate. The annual survey only asked employees to provide their home zip code, but home addresses were obtained in a subsequent step, by matching survey responses to the above employee database, using the EEID as the key. The resulting database had a collection of 2,746 responses which contained respondents' home zip code and mode choice on weekdays and 1,415 home addresses at the street level.

3.2. Employees from multiple employers

Additional data provided information on Los Angeles commuters in general in order to provide comparison and control against the sample of UCLA commuters. Employee residences at the zip code level and workplace data at the city level were obtained using the U.S. Census' "OnTheMap" tool. This tool provides

a) the number of employees working within a specific city as of 2006 ("same-city employee" for shorthand);
b) the top ten zip codes or the top ten census tracts where same-city employees resided and employee counts for each of these zip codes or census tracts in 2006; and
c) counts and percentages of the same-city employees with journey-to-work distances (linear distance) that were less than 10 miles, 10–24 miles, 25–50 miles, or more than 50 miles.

Given the above, "OnTheMap" provides one of the best data publicly available for the studies of jobs/housing balance at the city level in the U.S.

The American Community Survey (ACS) 2007–2009 Estimates and 2009 National Household Travel Survey (NHTS) data supplemented the "OnTheMap" data in terms of providing transportation mode and housing information of Los Angeles residents.

Three cities—Santa Monica, Culver City, and West Hollywood, California—were used as comparison groups in this study. These subjects were chosen because of four reasons.

First, these three cities are all within six miles of the UCLA campus (see Fig. 1). Therefore, employees from these cities and UCLA could be generally seen as in the same housing market as they were in similar proximity to the same housing options and amenities (see Figs. 2–4). The similar proximity reduces the odds

Fig. 1. Subjects of interest, freeways, and public transit services.
Source: created by the authors based on the ESRI Street Map Premium and Google Transit.

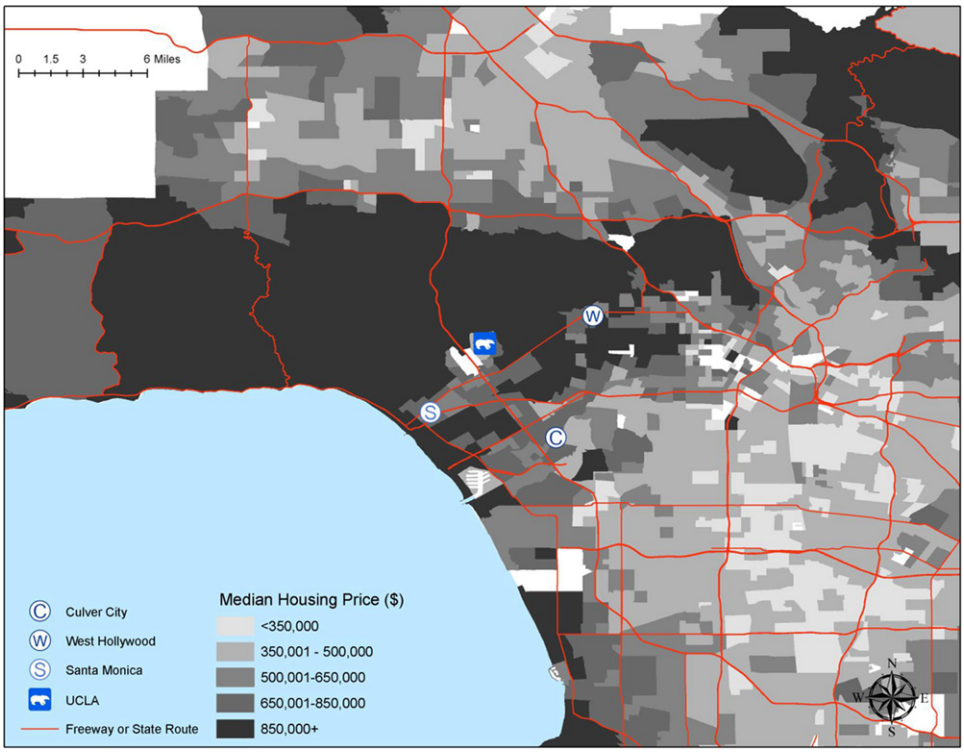


Fig. 2. Median housing prices around UCLA and the three cities.
Source: created by the authors based on American Community Survey 2007–2009 Estimates.

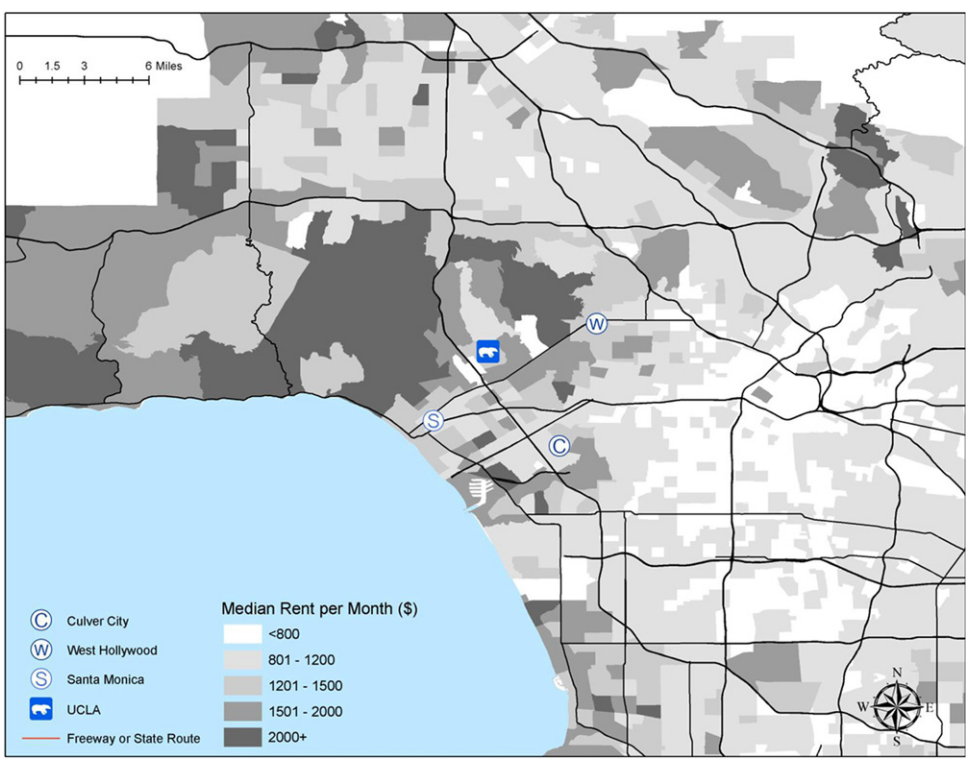


Fig. 3. Median rent paid by current tenants around UCLA and the three cities.
Source: created by the authors based on American Community Survey 2007–2009 Estimates.

that employees from one of the subjects had to choose residences farther away from their worksite to have certain housing options or amenities. If the odds were high, comparison of jobs/housing of these cities and UCLA would generate biased results.

Figs. 2–4 suggest that Culver City had more affordable housing options. Santa Monica had the highest median housing price in proximity, but it had a relatively affordable median rent. Both Santa Monica and West Hollywood had rent control, but UCLA

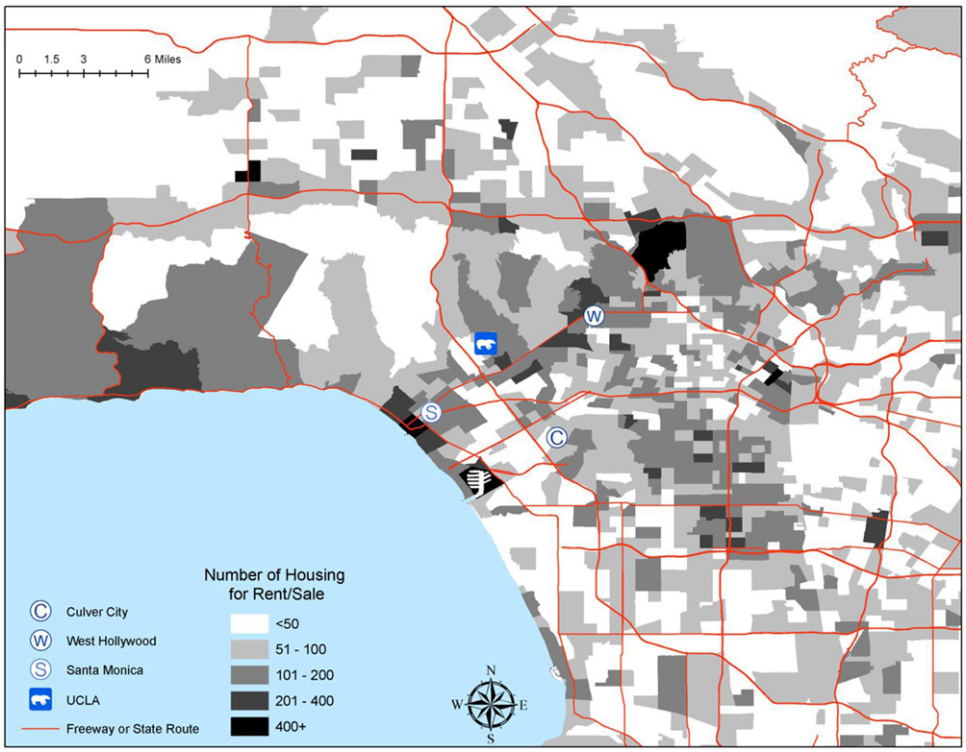


Fig. 4. Number of housing units for rent/sale around UCLA and the three cities.
Source: created by the authors based on American Community Survey 2007–2009 Estimates.

had higher housing prices as well as higher median rent than Culver City and West Hollywood. For all four groups, comparatively cheaper and more housing options were available in areas around and to the east of Culver City. Simply looking at the housing availability, levels of median rent, and median housing price, one might conclude that Culver City employees should have the best jobs/housing balance.

Second, the UCLA campus and the three cities are all well served by public transit or freeways (see Fig. 1). UCLA does not operate any bus services, but the campus is served by 14 bus lines of the Los Angeles Metro (LA Metro), Culver City Bus, Santa Clarita Transit and Santa Monica Bus. In addition to LA Metro express bus services, the cities of Santa Monica and Culver City operate their own bus lines, which cover the main corridors within their respective territories and beyond. Santa Monica City Bus has 14 lines (including two rapid lines) running between Santa Monica and other regional transit hubs such as Los Angeles's downtown, Los Angeles International Airport (LAX), and UCLA. Similarly, Culver City Bus has 8 lines (including one rapid line) running between Culver City and other regional transit hubs such as UCLA, Fairfax, Century City and Metro Green Line Station along Sepulveda Boulevard. The City of West Hollywood does not operate bus services on its own but has 12 LA Metro Bus lines passing through or within a quarter mile of its boundaries. Both the UCLA campus and the three cities are within two miles of at least one major freeway. Of course, due to difficulty in obtaining better transit and highway level of services data, the above facts or figures alone do not guarantee that both UCLA and the three cities are equally or similarly served by public transit or freeways. Readers should still be cautious that the variance in level of transit and freeway services could still contribute to the differences in mode choice and jobs/housing balance of employees from UCLA and the three cities.

Third, like UCLA, the three cities are all employment centers, each of which has at least 20,355 jobs, so that comparisons among the cities and UCLA are meaningful, as the subjects all attracted a large number of employees and thus jobs/housing for these subjects are important. Table 1 below summarizes the employment information of UCLA and the three cities. The five dominant sectors that offered the most jobs in the three cities and the 90024 zip code (representing UCLA) are in bold. Culver City has the highest share and number of Information jobs. Santa Monica has the highest share and number of Professional, Scientific, and Technical Services jobs. West Hollywood has the highest share of Retail Trade and Accommodation and Food Services jobs. Thanks to the contribution of UCLA, the 90024 zip code, as expected, has the highest share and number of Educational Services and Health Care and Social Assistance jobs. Given the above, a comparison of UCLA and the three cities might shed light on how employment sectors could affect employees' jobs/housing balance and mode choice. Notably, given the fact that the three cities have more diverse employment than UCLA, the comparison results are likely to be influenced by the agglomeration effects of diverse employment in the three cities. For instance, diverse sectors in one city offer diverse job opportunities for job seekers and their partners (if applicable) nearby so that they do not need to commute a lot. In turn, employees of this city could have better jobs/housing balance than those from a city/university that has highly concentrated and specialized employment, other things being equal.

Fourth, compared to the UCLA employees, employees in the three cities were from a variety of sectors and this contributes to disparity in income, age, and work schedule among them. For instance, the three cities had higher percentages of employees that were 29 or younger than UCLA (Table 1). UCLA faculty median earnings were the highest among all four employee categories (Table 2). Therefore, comparing the UCLA employees and those of the three cities could also show how income, age, and work schedule would influence employees' residential patterns and travel behaviors. Of course, university employees are very special in terms of their attitude towards TDM and sustainable transportation, as indicated by Toor and Havlick (2004) and

Table 1
Summary of employee information of the three cities and UCLA in 2006.
Source: the U.S. Census' "OnTheMap" tool.

	Culver city	Santa Monica	West Hollywood	UCLA[a]	90024 minus UCLA
Total employees	48,384 (100%)	69,752 (100%)	20,335 (100%)	27,113 (100%)	22,117 (100%)
Employees by age					
Age 29 years or younger	26.3%	30.3%	32.0%	16.7%	28.9%
Age 30 – 54 years	57.7%	56.8%	55.5%	70.0%	52.1%
Age 55 years or older	15.9%	12.9%	12.5%	13.3%	19.1%
Jobs by NAICS Industry Sector					
Mining, quarrying, and oil and gas extraction	0.0%	0.0%	0.0%	1.1%	–
Utilities	0.0%	0.5%	0.7%	0.0%	–
Construction	2.3%	2.9%	0.9%	0.7%	–
Manufacturing	3.9%	1.6%	1.5%	0.4%	–
Wholesale trade	5.0%	3.5%	4.3%	0.5%	–
Retail trade	**16.0%**	**13.1%**	**19.7%**	2.1%	–
Transportation and warehousing	1.2%	0.6%	2.9%	0.2%	–
Information	**23.5%**	**9.9%**	3.8%	2.9%	–
Finance and insurance	4.1%	4.2%	2.8%	3.0%	–
Real estate and rental and leasing	2.9%	4.5%	4.4%	1.6%	–
Professional, scientific, and technical services	**8.0%**	**15.5%**	**9.4%**	**5.6%**	–
Management of companies and enterprises	1.3%	1.3%	0.9%	1.0%	–
Administration and support, waste management and remediation	**8.2%**	3.6%	6.1%	3.0%	–
Educational services	**5.6%**	7.4%	1.8%	47.3%	–
Health care and social assistance	**5.6%**	**9.4%**	**7.3%**	**16.6%**	–
Arts, entertainment, and recreation	0.8%	2.7%	4.2%	1.3%	–
Accommodation and food services	4.8%	**12.5%**	**20.4%**	**4.9%**	–
Other services (excluding public administration)	4.8%	6.3%	**7.6%**	**7.7%**	–
Public administration	2.0%	0.5%	1.2%	0.0%	–

[a] Jobs by NAICS industry sector data were not available for UCLA and the table uses 90024 zip code area data from the U.S. Census' "OnTheMap" tool as replacement. UCLA accounts for 55% (27,113/49,230) of the total employment in 90024. The 90024 zip code area includes the UCLA campus.

Table 2
Jobs by Earnings in the Three Cities and at UCLA in 2006. *Source*: Information of the three cities was from the OnTheMap tool; information of UCLA was based on the UCLA employee database and only employees that worked at least 50% of the time at UCLA were considered.

	Culver city	Santa Monica	West Hollywood	UCLA All	UCLA faculty	UCLA staff	90024 minus UCLA
Jobs							
Earnings	48,434 (N)	69,752 (N)	20,335 (N)	26,763 (N)	3270 (N)	23,493 (N)	22,467 (N)
$1250 per month or less (%)	28.9	19.9	23.9	3.0	1.5	3.2	28.2
$1251 – $3333 per month or more (%)	33.7	35.1	42.7	22.7	1.0	24.8	35.9
$ 3333 per month (%)	37.4	44.9	33.3	74.2	97.5	72.0	36.0

Victoria Transport Policy Institute (2010). It is still likely that attitude would contribute to the differences in residential patterns and travel behaviors among different employee categories. eaders should keep this in mind.

3.3. Commute/residence data at the census tract level

The UCLA employees' commute/residence information at the census tract level was derived from the employee database and the SCAQMD survey mentioned above. The boundary files for the census tracts were from the U.S. Census website. The regional (Los Angeles) employees' commute/residence data by census tract were from the U.S. Census American Community Survey 2007–2009 Estimates, which are publicly available on the Internet. Travel times from different locations to UCLA used link-level travel times in the AM peak period as a part of the 2007 regional travel model output for the six-county Southern California Association of Governments region.

4. Jobs/housing balance and mode choice

Using the data highlighted above and ArcGIS 9.3, the authors obtained the following maps (Fig. 5) to examine the patterns of the UCLA employees' residences.

UCLA employees' homes are geographically dispersed. Almost every census tract in the gray area (approximately the Los Angeles County area) has at least one UCLA employee (Panel A of Fig. 5). UCLA employees are living as far as 50 miles away in the eastern parts of Los Angeles County, which is at least 60 min away from UCLA by automobile in AM peak hours.

Notably, there is also a higher concentration of UCLA employees' residences within a ten-mile radius of the campus. This effect maps very well when the concentration is measured by indicators such as absolute counts of residence per census tract or the number of residences per square mile by census tract. A tract about four miles southwest of UCLA stands out in the three maps in Panels A, B, and D of Fig. 5. A further check indicates that this tract is where the UCLA-owned University Village Apartments are located. In addition to married graduate students, these apartments are also intended for postdoctoral staff/employees at UCLA to rent at below market prices.[2]

In addition to the University Village tract, there are other clusters of UCLA employees' residences. For instance, several tracts about two to five miles southwest and southeast UCLA also

[2] See http://map.ais.ucla.edu/portal/site/UCLA/menuitem.789d0eb6c76e7ef0d66b02ddf848344a/?vgnextoid=3933064a9a7d1010VgnVCM1000008f8443a4RCRD for more details.

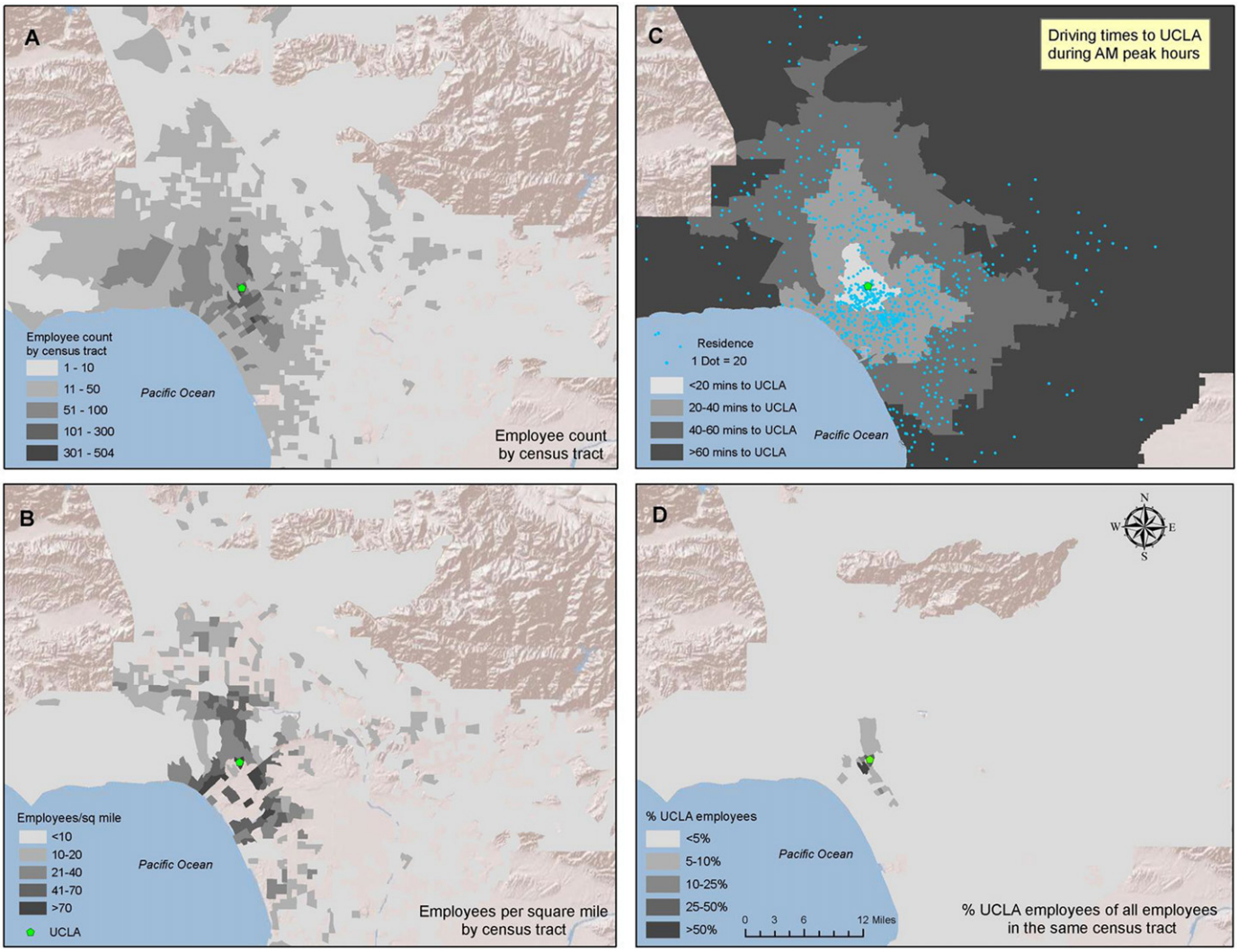


Fig. 5. UCLA employees' residences: patterns from different perspectives.
Source: created by the authors.

have a larger number of UCLA employees' residences or a higher density of such residences, as shown in Panels B and C. Further comparison of Figs. 1 and 5 indicates that these tracts with a higher concentration of UCLA employees' residences are also tracts better served by public transit services and freeways. These tracts have at least one direct bus line to UCLA. The tracts' centroids are less than two miles from Interstates 10 (I-10) and /or 405 (I-405). As a whole, employees working for the same employer may cluster both proximate to their common workplace and in places which have convenient public transit services and freeway connections.

Fourth, the majority of the residences are within a 60 min drive during peak hours from UCLA (see Panel C of Fig. 5). But despite the fact that housing prices were in general very high in areas around UCLA, many UCLA employees did manage to find residences in some relatively more affordable areas in the southeast (See Panels A and C of Fig. 5 and the UCLA panel of Fig. 6).

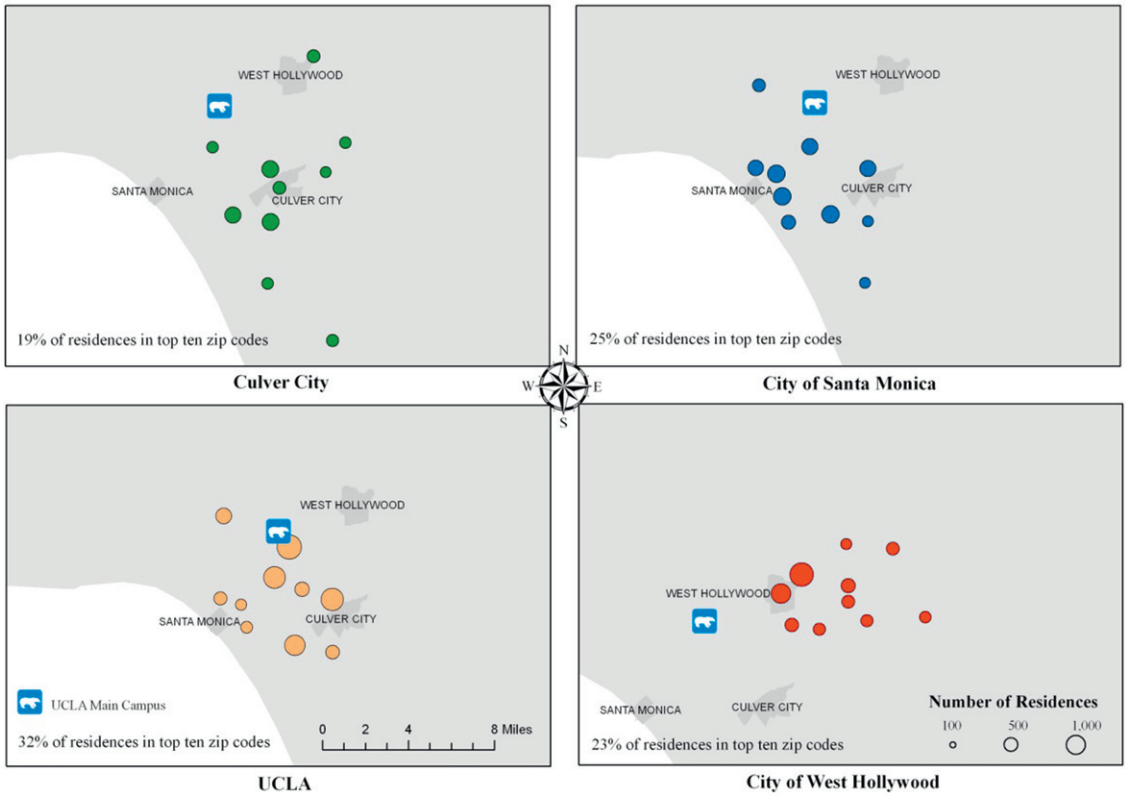
4.1. Employees' residences of different employers/workplaces

To explore whether the findings presented above are unique to employees working for the same employer, this study also examined jobs/housing balance of the employees working in three different cities with jobs/housing data provided by "OnTheMap". The maps based on the LED OnTheMap data are showed in Fig. 6, which compares the ten zip-code areas where the most UCLA employees live and the most employees of the three cities live.

For UCLA and all of the three cities' employees, the ten most popular zip codes where they chose to live are all within a ten-mile radius of their respective workplaces. This means that notable percentages of all employees (19–32% of all employees) did manage to live relatively close to their employers, in spite of higher housing prices and rents around their workplaces, as shown in Figs. 2 and 3. UCLA employees tended to have a better jobs/housing balance than the employees of the three cities. There are at least 32% of UCLA employees living within ten miles of their workplace, compared to only 19% to 25% of the employees of the three cities.

Housing prices around workplaces tended to have a mixed effect on the jobs/housing balance. For instance, Figs. 2–4 show that median housing prices and median rents around UCLA are significantly higher than those in and around Culver City, but a lower percentage of employees working in Culver City lived within ten miles of their workplaces.

Other OnTheMap data and the geocoded home addresses of the UCLA employees further substantiated the findings highlighted above. Table 3 compares the percentage of the same-city and UCLA employees by commute distance.



Culver City			Santa Monica			West Hollywood			UCLA		
Top 10 Zip Codes	Residence Count	% of All Residences	Top 10 Zip Codes	Residence Count	% of All Residences	Top 10 Zip Codes	Residence Count	% of All Residences	Top 10 Zip Codes	Residence Count	% of All Residences
90034	1,411	2.9%	**90066**	2,411	3.5%	**90046**	1,163	5.7%	**90024**	1,640	6.2%
90230	1,349	2.8%	**90405**	2,384	3.4%	**90069**	779	3.8%	**90034**	1,367	5.1%
90066	1,286	2.7%	**90404**	2,266	3.2%	**90028**	400	2.0%	**90025**	1,300	4.9%
90232	843	1.7%	**90034**	2,058	3.0%	**90048**	374	1.8%	**90066**	1,163	4.4%
90046	804	1.7%	**90025**	1,937	2.8%	**90038**	359	1.8%	**90049**	702	2.6%
90250	767	1.6%	**90403**	1,923	2.8%	**90027**	340	1.7%	**90064**	590	2.2%
90019	632	1.3%	**90291**	1,537	2.2%	**90036**	328	1.6%	**90230**	501	1.9%
90045	618	1.3%	**90049**	1,249	1.8%	**90004**	327	1.6%	**90403**	454	1.7%
90025	618	1.3%	**90230**	932	1.3%	**90026**	293	1.4%	**90405**	395	1.5%
90016	576	1.2%	**90045**	911	1.3%	**90068**	246	1.2%	**90404**	339	1.3%
Others	39,418	81.6%	**Others**	52,141	74.8%	Others	15,746	77.4%	**Others**	18,132	68.2%

Fig. 6. Comparison of jobs/housing balance of four employee groups.
Source: created by the authors based on the 2006 data from OnTheMap and the 2006 UCLA employee database; all the maps and legends are of the same scale.

Table 3
Employees by commute distance: the three cities and UCLA.

Distance	Culver city (%)	Santa Monica (%)	West Hollywood (%)	UCLA[a] (overall) (%)	UCLA (faculty) (%)	UCLA (staff) (%)	90024 minus UCLA (%)
Less than 10 miles	49.6	47.3	59.5	64.7	80.0	62.1	41.8
10 to 24 miles	31.9	34.3	25.3	25.6	15.0	26.9	36.5
25 to 50 miles	11.4	9.7	8.7	7.9	3.6	8.4	10.9
Greater than 50 miles	7.1	8.7	6.5	2.5	1.3	2.6	10.9

[a] UCLA N=26,763, faculty N=3,270, and staff N=23,493.

4.2. Mode choice comparisons: UCLA employees vs. LA employees

Now we turn to the question regarding whether employees of the same employer have different mode choice from employees working for different employers, given the variances in jobs/housing balance. Here, we obtained mode split of the UCLA employees at the census tract level based on the 2006 SCAQMD survey responses and mode split by census tract for all employees ("workers older than 16 years" as defined by the U.S. Census, "LA employees" as shorthand hereafter) in the same tracts from the ACS 2007–2009 Estimates. Given the fact that commute times of LA employees of the same modes were different throughout the ACS sample, one can be certain that LA employees were working for employers at different locales.

4.2.1. Geographical analysis: controlling residential locations

Fig. 7 below compares the mode choice of UCLA employees and that of LA employees, after controlling the origin (residential location and thus transit supply at the origin) of both groups.

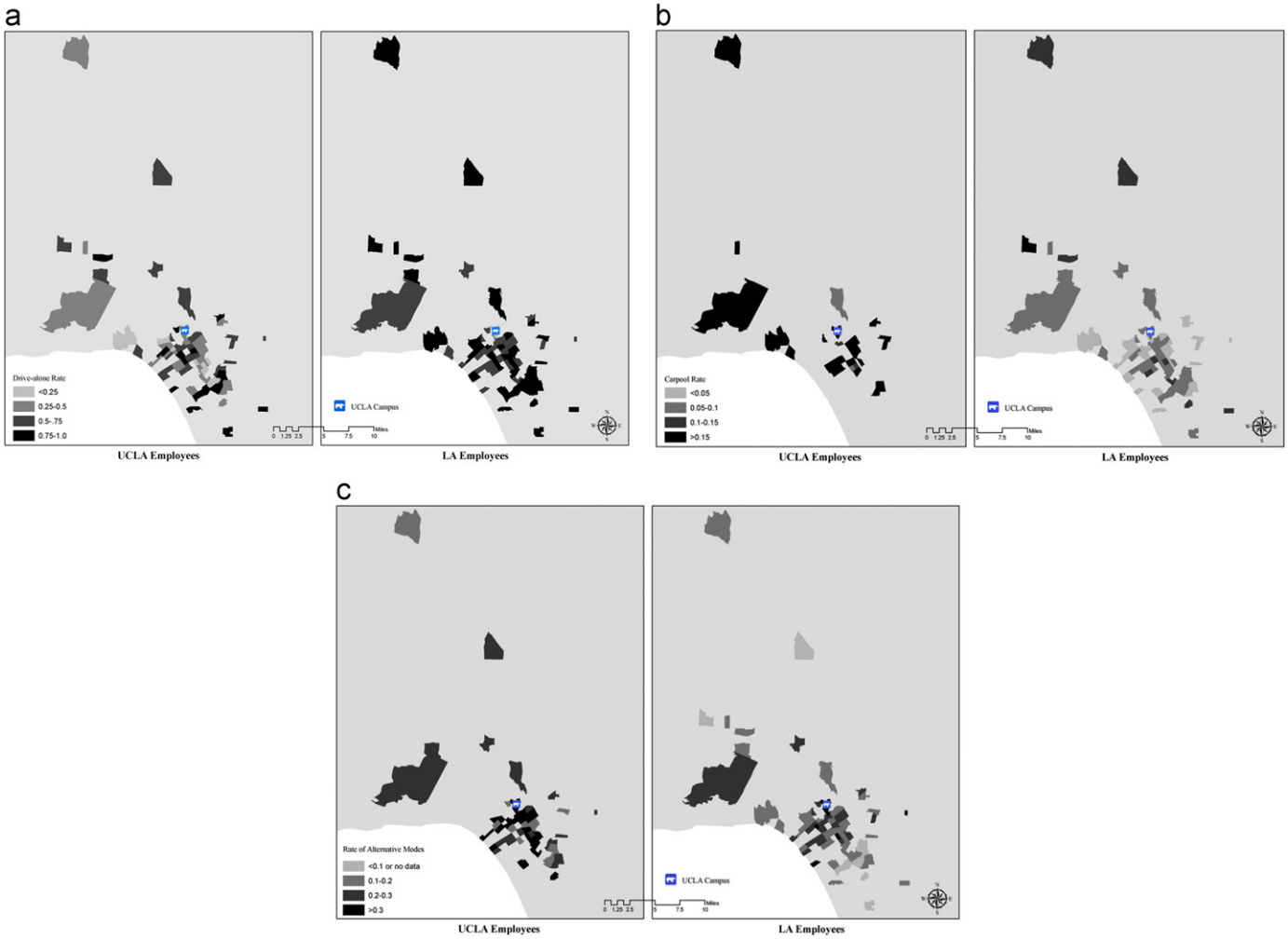


Fig. 7. Mode choice of UCLA employees and LA employees by census tract (a) drive-alone, (b) carpool and (c) public transit, walk, bike, or work at home.
Source: created by the authors based on the SCAQMD survey responses, the American Community Survey 2007 – 2009 Estimates, and the 2000 U.S. Census boundary maps of census tracts, using in the analyses only the 74 tracts with at least four SCAQMD survey responses.

After controlling residential location and public transit supply on one end of the journey to work, the UCLA employees drove less than LA employees in general (Fig. 7(a)). Of all the tracts studied, LA employees consistently had a rate of driving to work greater than 0.5. There were, by contrast, quite a few tracts where less than 50% of the UCLA employees drove to work. All 74 tracts combined, 58% of the UCLA employees drove to work while 74% of LA employees did so.

Based on these maps, it is not clear whether the UCLA employees carpool more than LA employees (see Fig. 7(b)). There were tracts where a higher percentage of UCLA employees carpooled to work, elsewhere a lower percentage of UCLA employees did so, and spatial patterns are not as evident. With all 74 tracts combined, however, 10% of the UCLA employees carpooled to work while 6% of LA employees did so.

In most tracts there were at least 10% of the UCLA and LA employees using alternative modes such as riding transit, biking, walking, and telecommuting. In areas south of UCLA, there was a higher percentage of the UCLA employees who used alternative modes. This, plus the information conveyed by Figs. 5 and 6, indicates that many UCLA employees not only managed a good jobs/housing balance but also more frequently used alternative modes. All 74 tracts combined, 30% of the UCLA employees used alternative modes to driving while 20% of LA employees did so.

4.2.2. Statistical analysis: controlling residential location

The geographical analyses presented above identified some descriptive differences in the mode choice of the UCLA employees and other employees after adjusting for residential location and transit services on one end of the commute trip. Table 4 summarizes the paired *t*-test results, which show whether the means of different mode choices of the UCLA employees are significantly different from those of LA employees. To reduce possible biases caused by a small sample size, only nine census tracts with at least ten UCLA employees were used in the *t*-test.

The paired *t*-test results indicate that the UCLA employees were significantly less likely to drive alone to work than LA employees ($p=0.001$). Also, the odds for UCLA employees to commute by alternative modes were significantly higher than for LA employees ($p=0.05$). On average, UCLA employees had a higher rate of carpooling than LA employees. But this was not proved statistically significant at the level of $p=0.1$. On average, UCLA employees were ten times more likely to vanpool than LA employees, but overall this was also not statistically significant.

4.2.3. Statistical analysis: controlling commute time and/or income

The above analyses show that the UCLA employees were more likely to use alternative modes than LA employees when they

Table 4
Mode choice of UCLA employees vs. LA employees by census tract.

	Drive-alone	Carpool	Vanpool[a]	Alternative modes[b]
UCLA Mean	0.58	0.10	0.02	0.30
UCLA Max.	1.00	0.80	0.80	0.91
UCLA Min.	0	0	0	0
UCLA Variance	0.06	0.02	0.01	0.05
N (Tracts)	*74*	*74*	*74*	*74*
LA Mean	0.74	0.06	0	0.20
LA Max.	0.84	0.20	0.03	0.75
LA Min.	0.20	0.02	0	0.05
LA Variance	0.01	0.00	0.00	0.01
N (Tracts)	*74*	*74*	*74*	*74*
t value[c]	5.756	1.111	1.511	3.816
p (2-tailed)	0.0004	0.2989	0.1693	0.0051

[a] For LA employees, those carpooled with four or more people were treated as "vanpool". At UCLA, the university operated its own vanpool program, which used vehicles serving five to eleven passengers.
[b] Including public transit, walking, biking, and work at home.
[c] Paired *t* test for nine census tracts where there were at least ten UCLA employees.

Table 5
Mode choices of UCLA and LA employees by commute time.

Times (minutes)	UCLA employees (N=1269)		LA employees[a] (N=5,369)	
	Driving[b] (%)	Alternative modes[c] (%)	Driving[b] (%)	Alternative modes[c] (%)
0–10	45.6	54.4	92.5	7.5
10–20	54.9	45.1	95.3	4.7
20–30	62.2	37.8	94.1	5.9
30–40	79.6	20.4	94.0	6.0
40–50	71.0	29.0	89.8	10.2
50+	82.3	17.7	78.4	21.6
All	55.0	45.0	90.7	9.3

[a] Based on Los Angeles CMSA samples in 2009 NHTS dataset.
[b] Including driving-alone, carpooling, and vanpooling.
[c] Including public transit, walking, biking, and telecommuting.

both lived in the same census tracts. But that does not take into account commute distance/time and income of employees. In other words, it is still likely that the UCLA employees used alternative modes because they have shorter commute distances and higher income. To reduce the noise caused by commute distance, Table 5 compares the mode choices of the UCLA employees and LA employees after controlling one-way commute times by driving.

From Table 5, the UCLA employees were still greener commuters in most cases after we controlled commute time. The UCLA employees relied more on driving than their LA counterparts only when commute times are greater than 50 min. If commute times are less than 50 min, they consistently commuted more frequently with alternative modes.

Table 6 below compares the mode choices of the UCLA employees and LA employees after controlling one-way commute times by driving as well as income levels.

Table 6 confirms that the UCLA employees were still greener commuters in all cases except one: the UCLA employees who earned less than $30,000/year would rely more on driving than their LA counterparts if commute times are greater than 50 min. Other than this occasion, all other UCLA employees consistently relied less on driving than their LA counterparts. This indicates that there were factors other than jobs/housing balance (using commute time as a proxy) and income that contributed to greener mode choice at UCLA.

Table 6
Driving rates of UCLA and LA employees by commute time and by annual income.

Time (min)	UCLA (N=1269), income(1,000$)				LA employee (N=5160), income(1000$)			
	<30 (%)	30–60 (%)	60–100 (%)	100+ (%)	<30 (%)	30–60 (%)	60–100 (%)	100+ (%)
0–10	33.3	35.0	68.8	40.0	90.5	94.8	96.1	93.8
10–20	60.0	35.9	70.6	62.5	94.2	97.1	97.5	97.5
20–30	47.1	61.0	63.3	69.0	90.4	97.9	96.9	94.0
30–40	62.5	78.3	81.0	87.8	87.9	96.7	98.0	95.8
40–50	44.4	69.8	78.7	86.7	88.9	90.1	94.6	93.8
50+	75.0	83.9	81.5	84.2	63.2	86.3	88.7	84.5
All	46.2	60.8	53.8	62.4	88.9	95.0	95.9	93.6

5. Factors affecting jobs/housing balance and mode choice

The above analyses and comparisons suggest that the UCLA employees as compared to other employee groups were

a) maintaining a better jobs/housing balance as reflected by a higher percentage of employees living within short distances to worksite;
b) significantly less likely to drive alone to work; and
c) significantly more likely to use alternative modes than driving-alone, even after controlling residential location, income, and/or commute time.

Which factors then contribute to the differences in jobs/housing balance and mode choice between the UCLA employees and other employee groups? Looking at existing studies and facts at UCLA, there could be two factors.

First, university employers tend to offer more TDM measures (including subsidized housing options near workplace) and sustainable transportation programs. Toor and Havlick (2004) and Victoria Transport Policy Institute (2010) show that universities are more friendly to staggered hours or telecommuting, TDM measures were effective among university employees/students, and TDM measures have been and are being pursued by many universities and colleges. In addition, colleges and universities are probably more aggressive than other employers in promoting sustainability, of which jobs/housing and sustainable transportation are two important components. This is evidenced by the collective initiatives of ACUPCC, as well as by individual actions at universities (e.g., UCLA Transportation 2011). Table 7 summarizes the TDM-related measures and housing-related programs at UCLA, estimates their effects on jobs/housing balance and on mode choice, and compares the measures or programs at UCLA and elsewhere in Los Angeles, if possible.

Second, university employees, faculty members in particular, have higher income than employees from the other sectors. In this study, the median income per month for same-city employees was lower than $3333 while the median income per month for UCLA employees was higher than $3333 (see Table 2). Therefore, generally speaking, the latter can afford closer and more costly housing, so they lived around UCLA.

The following summarize the TDM measures implemented at UCLA, their respective estimated impacts on mode choice and their respective "customers".

5.1. Subsidized transit passes

By collaborating with various transit operators in the region, UCLA offered its employees (in most cases, students also) 50% off transit passes. Other than UCLA employees, only Santa Monica College employees enjoyed similar commuter benefits in Los

Table 7
Summary of the TDM measures and housing-related programs at UCLA.

Measure or program	Sub-measure or sub-program	Contents	Effects	Comparison
Subsidized transit pass	Monthly pass for Santa Clarita T ransit BruinGo Flashpass LADOT Pass	At least 50% subsidy for employee riders	Up to 8% more employees using public transit	Few employers in Los Angeles provide such a heavy subsidy to employee transit riders.
Subsidized vanpool program	Subsidy for vanpoolers	UCLA subsidy is 35% (operating costs) and 49% (operating costs and administration overhead).	1650 regular employee vanpoolers, which can be translated into a minimum 5.5% ([1650-160]/ 27,113) reduction in driving-alone among all employees.	Having 160+ vans, UCLA probably has the biggest employer- run vanpool program in the U.S.
	Commuter support for vanpool passenger and drivers	UCLA passengers who have unexpected overtime or family emergency are eligible for one (1) free emergency ride home (car rental); vanpool drivers are eligible for up to two (2) in a three month period.	Unknown	-
Discounted carpooler parking permit	-	$52/month for a 2-person carpool permit and $33 for a 3-person carpool permit vs. $63/month for a typical solo-driver permit	1091 employee carpoolers in 2009	Few other parking facilities in Los Angeles offer any discount for carpoolers.
Carsharing	Zipcar on campus	20 cars on 12 locations on and around campus for registered employees to use at a rate of $7.5/hr	581 registered member as of 2010	Most Zipcar vehicles in Los Angeles are located on or around university or college campuses.
Ridesharing support	Zimride	An online ridematching services which integrates Facebook, allows users to share a ride with the UCLA network	Unknown	Few other employers in Los Angeles have such services.
University-run shuttle services	-	Two shuttle routes help employees and students travel on and around campus	4902 riders/day in 2006	Few other non-university employers in Los Angeles have such services.
Overall TDM measure/program expenditure	-	$7 million per year	$259/employee/year	-
University-owned housing options for faculty/ postdoctoral employees	Faculty housing program	214 housing units within five miles of the campus available to faculty at a price lower than the market one	Possibly reduce drive-alone trips	Few other non-university employers in Los Angeles provide housing for their employees.
	University Village Apartments	1000+ housing units within five miles open to married students and postdoctoral employees		
Housing rental support	-	On-line listing services	Unknown	
		Rental coordinator to help find best housing options near campus	Unknown	
Childcare	Childcare facilities on campus for all employees/ students	Quality childcare at a price that is competitive in the market	Unknown	Few other non-university employers in Los Angeles provide such services to their employees.

Angeles. The BruinGo Program was one of the most famous subsidized transit pass programs at UCLA. According to previous research, the fare-free BruinGo alone increased public transit ridership among UCLA employees between 50% and 55% one year after it was introduced (Boyd et al., 2003; Brown et al., 2003). A longer look into the UCLA employee mode split data indicates that between 1990 and 2000 when UCLA offered no subsidized transit pass to employees, the percentage of UCLA employees took public transit to work ranged from 6.4% to 9.25% from year to year. Between 2001 and 2011, when UCLA had various transit passes available to its employees, the percentage of UCLA employees commuting by public transit ranged from 11.1% to 15.5%. If we treat the above two decades of public transit rates as paired samples ($n=11$ for each sample), a t-test indicates that the transit rates for the two decades are statistically different ($p=0.0001$ and t-value$=17.515$). Assuming other factors had been constant or changed very little, the introduction of subsidized transit passes has significantly increased the public transit rate of UCLA employees. The funding for the subsidized transit passes came from the parking sales revenue that UCLA collected. Discounted transit passes were attractive to UCLA employees of different income levels (see Table 8). Between 2006 and 2007, 2% of all UCLA employees ($n=523$) frequently used a subsidized transit pass and did not hold a permit for on-campus parking.

5.2. Subsidized vanpool program

UCLA has one of the largest employer-subsidized vanpool programs in the U.S. This program has 160 11-passenger vans and serves over 80 communities in the Los Angeles region. As of 2006, about 1500 UCLA employees (5.5% of all employees) participated in the UCLA vanpool program. Using the revenue from on-campus parking permit sales, UCLA subsidized 35 – 49% of the cost to operate and administrate the UCLA vanpool program. The subsidy made the vanpool fare rather affordable. For instance, for an employee vanpooler residing in Orange

Table 8
Discounted transit pass holder and vanpoolers by income band.

Annual income (1,000$)	Percentage of all	
	Discounted transit pass holders (N=523)	Vanpoolers (N=1274)
<30	17	4
30–60	58	57
60–100	18	33
100+	7	6

County, which is about 45 miles from UCLA, she or he only paid $130 to $175 per month ($3 per trip) to enjoy a round trip every weekday between her or his residence and UCLA. In contrast, the fare for a one-way ten-mile trip from UCLA to the Los Angeles Airport was $5 on a 25-passenger bus and $18 plus tips on an 11-passenger shared van. In addition to affordable fares, UCLA vanpoolers were eligible for a free emergency ride home for every three months. Like discounted transit passes, the UCLA vanpool program attracted UCLA employees of different income levels.

But both discounted transit pass and vanpool programs were most popular among employees who earned $30,000 to 60,000 per year.

5.3. Discounted carpool permit

At UCLA, the cheapest monthly parking permit cost $63 for a solo driver in 2006. But if an employee carpooled with other employee(s), his or her permit could cost almost half of that amount. For instance, a two-employee permit cost $52 and three-employee permit cost $33. In 2006, 941 UCLA employees (3% of all employees) carpooled. Of these carpooling employees, 6% earned less than $30,000, 51% earned between $30,000 and $60,000, 27% earned between $60,000 and $100,000 and the remainder earned more than $100,000 per year. Employees earning more than $100,000 tended to like carpooling. Of all the carpooling employees, as high as 14% earned more than $100,000, while of all UCLA employees, only 11% earned more than $100,000.

5.4. Carsharing

There were 20 shared-use vehicles deployed by Zipcar (formerly Flexcar) at multiple locations on and around the UCLA campus since 2005. UCLA waived the fee of on-campus parking for Zipcar. No formal studies of UCLA Zipcar users (zipsters) had been conducted at the time of this writing. But as of 2010, there were 282 UCLA employees (1% of all employees) registered as "alternative commuters," and as a result, they enjoyed eight hours of free usage of Zipcar. In terms of income, almost all (99 percent) of UCLA zipsters earned between $30,000 and $100,000, according to the 2009 UCLA Zipster Survey. It is not clear how Zipcar had affected mode choice of UCLA employees. But if we think that the carsharing experience in San Francisco is transferrable to UCLA, then the presence of Zipcar at UCLA might have such influences: suppressed car ownership, more judicious and selective use of cars for particular trip purposes, and multiple-occupant carshare trips (Cervero, 2003; Cervero and Tsai, 2004). In the three cities used as references to this study, there were no shared-use vehicle programs.

5.5. Other transportation-related programs

In addition, UCLA offered exclusive and free on-line services called Zimride via a contractor to help ridesharing among its students and employees and operated shuttle services to move employees and students on and around campus. Due to the lack of data, it was not clear how these services had affected UCLA employees' residence choices and travel behaviors. As of 2011, there were 4661 Zimride subscribers at UCLA. In other words, as many as 8% of UCLA members (students and employees) had used Zimride at least once.

5.6. Housing-related programs

Through a first-come, first-served application, UCLA offers about 1200 housing units at lower than market rates. All of these units are within five miles to the campus. Some of them are even within walking distances to the campus, like the Gayley and Levering faculty units (n=144) around the campus. For the 1000 units open to married graduate students and postdoctoral staff only, there are three bus routes within walking distance that go to UCLA directly. Every year, about 370 faculty and postdoctoral employees live in these units (1.3% of all employees); the rest go to students.

In addition, UCLA employees can send their children to two childcare facilities on campus and one off-campus near the university-owned housing complex located only 5 miles south of the campus and with easy access to two freeways (I-405 and I-10).

6. Costs to influence jobs/housing balance and mode choice

The above programs cost UCLA millions of dollars to run. For employers smaller than UCLA, few of them are able to afford such a comprehensive TDM and housing-related program on their own. Based on the UCLA experience, it might be cheaper and more feasible for them to run individual programs such as discounted carpool permits, on-line ride-matching, and discounted transit passes. But it can be prohibitively expensive for them to run a viable vanpool program or a shuttle program (see Table 9). Given the effects of different TDM programs on reducing driving needs of employees (see Tables 7 and 9), however, it might still be worthwhile for them to pool limited resources to offer a TDM program that has multiple components that are mutually supplementary. In addition, the UCLA TDM experience indicates that most TDM programs can be enjoyed by employees of all income levels.

Where there are multiple employers that cluster spatially and many employees live in proximity, pooling resources could be beneficial to all contributing employers. First, reducing driving needs of employees and increasing mode options might make employers more attractive to employees and show their efforts towards a more sustainable future against the backdrop of global climate change.

Smaller-sized employers in a collective or coalition might also bargain to get a better deal with local transit agencies or contractors that help implement different TDM programs such as discounted transit passes for a given route or a vanpool program. The success of Groupon, for instance, shows how a group of customers could get deep discounts on a product or service while both customers and merchants come out ahead (Steiner, 2010). For TDM, transit agencies and contractors face inefficiencies in offering services to a limited customer base (Mohring, 1972). By packaging services to smaller employers that are spatially clustered, discounted passes or Zipcar services might become more cost-effective, and therefore, smaller employers might be able, as a group, to attract contractors like Zimride at better, high-usage rates.

Table 9
Costs of TDM programs.

Program	Participant status	Participants or subscribers	Average commute distance (miles)[a]	Possible number solo drivers reduced[b]	Overall annual cost[c] ($1000)	Average cost to reduce one solo driver ($)
Vanpool[d]	Employees	1128	40	620	1637	2473
	Students	201		42		
Carpool[d]	Employees	967	14	298	174	416
	Students	1140	5.7	120		
Campus Expresse	Employees	480	2	264	1,807	2164
	Students	2720		571		
Discounted transit pass[f]	Employees	2243	12	1233	1147	
	Students	9941	5.7	397		703
Zimride	Employees and students	4661	–	–	7.2	–

[a] Based on the 2006 UCLA SCAQMD survey data and 2007 UCLA Spring student survey data.
[b] Assuming that (1) if there were no TDM programs, TDM participants would have the same mode choice as that reflected by 2006 UCLA SCAQMD Survey, (2) if there were no discounted transit passes, 4% of current student transit riders would drive alone to and from campus, according to Boyd et al. (2003), which studied mode share of UCLA students before and after UCLA introduced discounted transit programs, and (3) principal drivers who currently carpool or vanpool would drive alone to work.
[c] Real numbers provided by UCLA Transportation's Finance Group, including administration overhead.
[d] Real numbers from UCLA's vanpool/carpool program in 2007.
[e] Estimates based on the 2007 UCLA Campus Express survey.
[f] Estimates based on UCLA's 2006 SCAQMD survey data and 2007 Student Travel Survey data.

7. Conclusions and discussions

Using data from multiple sources, this paper has explored the following questions that few other papers have examined:

a) whether employees working for a large employer such as a university have a better jobs/housing balance and greener mode choice;
b) which factors have potentially contributed to a better jobs/housing balance and greener mode choice for such employees; and
c) what lessons can be learned from the answers to questions (a) and (b).

This paper found that employees working for a large employer do have a better jobs/housing balance and greener mode choice. In addition to considering factors that existing studies had identified, this paper showed through real-world cases that higher income levels are positively related to a better jobs/housing balance. Comprehensive TDM programs contribute to greener mode choice, but participation in those TDM programs also depended on income. UCLA's different TDM programs appeal to different income groups, and the very lowest income group at UCLA appears to be less able to use the TDM programs. One reason is that many of these lower income workers commute long distances in order to be able to afford housing in the Los Angeles region. While UCLA's many programs do benefit employees and contribute to raising UCLA's share of green commuters, not all employees are in a position to share in the programs. This finding is particularly important given how costly it is for low-income wage earners to keep a car. Nonetheless, given mapping done here, the rents and housing prices appear to be sufficiently high that they outweigh the high costs of commuting by car. Housing for lower wage, less-skilled workers has seldom been a priority for employers, and with steep cuts to higher education budgets throughout the U.S., it will be difficult to establish new programs.

The descriptive findings show that a good jobs/housing balance could lead to greener mode choices. But there might be other factors at work explaining why employees do not or cannot become green commuters. Only when we understand these factors better could we expect to incentivize more green commuters. These are the areas this study has not covered and can expand into in the future.

This study compared public transit ridership before and after BruinGo was adopted at UCLA. It also compared the public transit rates at UCLA for two decades to estimate the impacts of various subsidized transit passes at UCLA on public transit rate of UCLA employees. Due to data availability, however, we were not able to do more mode choice and jobs/housing comparisons before and after UCLA launched different TDM or housing programs. Meanwhile, we are fully aware that horizontal comparisons of the mode choice and jobs/housing balance between UCLA employees and other employee groups could be biased as other than controlled variables such as income, commute distance, and residential location used in this study, there could be other factors such as environmental awareness and flexibility in work schedule affecting mode choice and jobs/housing balance. After all, university employees might carry some unique characteristics when deciding to how to commute and where to live. In the future, conducting in-depth surveys of different employee groups should be able to reduce such bias as well as to disclose more individual motivations and characteristics underlyingmode choice and residential location decision. This study can serve as a stepping stone for that.

Based on the experience of UCLA TDM programs and Groupon, nevertheless, for smaller employers who are interested in reducing drive-alone among commuting employees, they can start with individual TDM programs such as exclusive on-line ride-sharing services, discounted transit passes and cheaper permits for carpooling employees. For smaller employers who cluster in space or have employees living inproximity, they can consider pooling resources together to offer a TDM program with multiple components, especially where there are third-party transit agencies and contractors involved. This cooperation would help them overcome the barrier of providing TDM on their own and perhaps leverage some of the scale benefits of larger customer groups to third-party vendors or contractors who might handle the information or transaction costs of managing carpools, subscriptions, or shared ride vans.

All in all, even though the car and drive-alone commuting still dominate, there is hope.

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