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Accessibility Evaluations of the Proposed Road User Charge (RUC) Program in California

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Abstract

This paper explores the impact of road user charge (RUC) in California on 'attractiveness' of manufacturing industry sectors by use of potential accessibility changes. The changes are evaluated resulting from RUC implementation for the future year of 2019 and using year 2013 as the base period. The evaluation of RUC impact on the manufacturing industries is carried out using considering four vehicle fuel-types of gasoline, compressed natural gas (CNG), diesel and electric for both rural and urban counties of California. The average percentage change in potential accessibility for counties (whether rural or urban) from 2013 to 2019 for the manufacturing sector are found to be higher for the 30-mile threshold as compared to the 20-mile threshold, across all four fuel-type vehicles that can be used for commuting. This exploratory analysis, we believe, could encourage some proactive public policy decisions for deciding RUC fee for other similar regions in the United States contemplating on implementing road user charge.

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Keywords: Manufacturing; employment; road user charge; gasoline; electric; accessibility

1. Introduction and Background

The fuel tax or gas tax has been the source of funding for preservation and maintenance of transportation infrastructure in California. Recently, there was an increase in gas tax by the legislature in California which is also

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looking at alternate sources of funding which are more sustainable, such as the road user charge (California Road Charge Pilot Program, 2017). Road user charge (RUC) is a form of road pricing where drivers pay directly for using a roadway. In 2016, to understand the feasibility of an alternative means of transportation funding, the State of California facilitated exploring and conducting a pilot program for RUC. The aim was also to gather public opinion, address privacy and data security, and provide at least one non-technological reporting method option through the pilot program. With a total of 5,129 vehicles that volunteered to participate statewide, 87% of the vehicles were private vehicles, 5% light commercial vehicles, 1% heavy commercial vehicles and 7% other vehicles participated in the pilot study which officially concluded on March 31, 2017 (California Road Charge Pilot Program, 2017).

Findings from the recently concluded California Road Charge Pilot Program showed significant enthusiasm from the public regarding road charge (California Road Charge Pilot Program, 2017). Around five thousand participants volunteered for the road charge program and it is anticipated that this number will increase significantly once enrolling in road charge program becomes mandatory in California. A mandatory public participation for the program in California will require all drivers (whether driving electric, hybrid or gasoline vehicles) to pay for miles they drive on roads. When road charge is used as a revenue generation mechanism, the program will also require the public to choose from among available payment methods, be able to switch from one payment method to another and allow enrolled participants to monitor any discrepancies (if any) in billing vis-à-vis the miles they drive. The authorities entrusted with road charge implementation will be required to ensure effective public announcement of the program and encouraging Californians to enroll and pay – all these by ensuring efficient revenue management with minimal faults or errors.

Countries in the European Union (such as Austria, Bulgaria, Czech Republic, Hungary, Slovakia, Romania and Slovenia) deploy vignette system to achieve the objectives and purpose of a road user charge (RUC) system (Mobility and Transport European Commission, 2010). Drivers in London and Stockholm pay hefty congestion charges just for entering the heart of the city (The New York Times, 2017) and this is also evident from the Congestion Charging zones that have been created in London. Introduced in 2003, the aim of the London Congestion Charging was to reduce congestion, improve bus services, journey time for car users and distribution of goods (Transport for London, 2016). For a motor vehicle operating in the Congestion Charge Zone (CCZ), on weekdays between 7:00 am – 6:00 pm the charge is £ 11,50 per day. There are no charges for the weekend, public holidays and between Christmas Day and New Year’s Day. Access to CCZ is free to all-electric cars, some plug-in hybrids, and any vehicle that emits 75g/km or less of CO_2 and meets the Euro 5 emission standards for air quality (Saarinen, 2017).

In Stockholm, Sweden, the tax is paid for some 18 different charging points located in different parts of the city with the highest during rush hour periods -7:00 am – 8:59 am and 3:30 pm – 5:59 pm (Swedish Transport Administration, 2015). The charges range from SEK 11 ($1.32, as on October 30, 2017) to SEK 30 ($3.59, as on October 30, 2017). The method of payment involves sending an automated camera picture taken of the vehicle's registration plate at the charging point to the Swedish Transport Agency where the vehicle is identified. Then the Swedish Transport Agency sends a payment slip to the vehicle’s owner if the vehicle is registered in Sweden. For a vehicle registered abroad, the Swedish Transport Agency has entrusted a notification partner to identify the owner of the vehicle and sends out invoices to and obtain payments from the owner of the vehicle via EPASS24 (Congestion taxes in Stockholm and Gothenburg, 2017). Emergency vehicles, EC mobile cranes and buses with a total weight of at least 14 tons, motorbikes and mopeds are exempt from paying the congestion charge.

For the cities of Bergen, Oslo and Trondheim in Norway, no incentives, discounts or exemptions were meted out to public for road charge. In fact, the program did not launch as public opinion was against the congestion pricing. Similarly, in Edinburgh, Scotland, road charge program did not launch as public voted against it.

Road charge can be integrated with the gas tax or can even completely replace the gas tax at some point in time after its successful launch and implementation – as being observed in Oregon (OreGO, 2018). This could result in changes in the generalized cost of travel (comprising road charge and/or gas tax) for Californian motorists. There is little knowledge how this might affect driving among labor workforce attributed to key industry sectors of California that support its economy. This paper is mainly focused on developing an understanding of the industry-specific ‘attractiveness’ due to RUC policy implementation in California.

To develop a further understanding of the integration, impacted by a future implementation of RUC in California, potential mobility measures of motorists such as accessibility should be developed and any related impact on the state’s future economic growth potential because of RUC should be assessed. This paper carries out the analysis of potential accessibility changes for workforce employed in counties across manufacturing industry sector of California. The industry clusters with locations having more than 500 workers are selected for analysis. The employment data used are from the latest year 2015 Longitudinal Employer-Household Dynamics (LEHD) (LEHD, 2018). Most of the manufacturing industry clusters are in the urban counties of San Francisco, San Matteo, and Almeda in the north and Los Angeles and San Diego in the southern region of California.

2. Formulation

Accessibility is often interpreted as opportunities available to people and firms to reach places (Gutiérrez, 2001; Linneker and Spence, 1992) and some form of cost (such as generalized cost, time etc.) is incurred in accessing those opportunities. While a net change in travel costs such as travel time between an origin and a destination can also be a direct measure of accessibility (Iacono and Levinson, 2011), incorporating employment component in an accessibility measure could result in true assessment of any benefits derived from distance traveled by commuters (Chandra and Vadali, 2014). In this paper, we use a very basic measure of accessibility but one that is also strong enough to represent the economic geography of a region through employment numbers and capturing mobility of commuters and representing the cost of travel as impedance. Therefore, the potential accessibility (PA or $PA_{f,i,t}$) for a county i with employment or opportunity accessed by a vehicle with fuel type f = gasoline, compressed natural gas (CNG), diesel, electric or hybrid in a given time period t is defined as,

$$PA_{f,i,t} = \sum_{j} \frac{E_{j,t}}{F\left(I_{f,i,j,t}\right)} \tag{1}$$

where, $E_{j,t}$ is the opportunity, such as the place-of-work or place-of residence employment, of county i at a given time t and $F\left(I_{f,i,j,t}\right)$ is the impedance function, with $I_{f,i,j,t}$ as distance, travel time, fuel cost etc., between the county i for which the accessibility is calculated and another county j in the study region. The function $F\left(I_{f,i,j,t}\right)$ is the impedance decay from the gravity accessibility model proposed by Hansen (1959) and has the following basic form,

$$F\left(I_{f,i,j,t}\right) = I_{f,i,j,t}^{\alpha} \tag{2}$$

The potential accessibility in Eq. (1) is a gravity-based form of measure and the Eq. in (2) requires estimation of an impedance-decay parameter α. The magnitude of α denotes the extent to which accessibility effects vary with impedance and it also shows the propensities to travel in relation to trips. Calibration of α generally requires impedance data and often its value is assumed to be equal to 1 when travel-demand data are unavailable or difficult to obtain (Gutiérrez, 2001; Linneker and Spence, 1992; Chandra et al., 2013).

The PA measure represented in Eq. (1) is empirically constructed and represents a direct relationship between employment of a region (often called 'opportunity' or market) and is inversely proportional to the impedance between studied counties representing the travel cost (including RUC) incurred with the impedance expression in Eq. (2). Thus, the expression in Eq. (2) can be expanded for impedance, as:

$$F\left(I_{f,i,j,t}\right) = I_{f,i,j,t}^{\alpha} = \left\{\left(\beta_{f,j,t} + \lambda_{j,t}\right)\left(X_{f,j,t} / \omega_{f,t}\right)\right\}^{\alpha} \tag{3}$$

where,

$\beta_{f,j,t}$ = the price of fuel f for a zone (county) j at time t

$X_{f,j,t}$ = distance in miles covered with fuel type f, for zone (county) j at time t

$\omega_{f,t}$ = the average mileage for vehicle with fuel type f at time t, and

$\lambda_{j,t}$ = RUC per gallon in a zone (county) *j* at time *t*.

Therefore, the final expression for potential accessibility $PA_{f,i,y,m}$ from Eq. (1) is,

$$PA_{f,i,t} = \sum_j \frac{E_{j,y}}{\left\{\left(\beta_{f,j,t} + \lambda_{j,t}\omega_{f,t}\right)\left(X_{f,j,t}/\omega_{f,t}\right)\right\}^{\alpha}} \tag{4}$$

We use cost based on RUC to a county from all other counties for computing impedance in Eq. (4). Percentage change in PA from 2013 to 2019 (probable year of road charge implementation in California) for counties using Eq. (4) is calculated as a measure of gain or loss in RUC-based accessibility. The percentage change in PA is calculated as ‘year 2019 PA (with RUC) minus ‘year 2013 PA (without RUC)’ and the difference divided by ‘year 2013 PA (without RUC)’. The ratio is multiplied by 100 to get the percentage value. Chandra and Vadali (2014) justify this kind of PA measurement since by using a percentage change in PA normalizes the potential accessibility change for different analyzed zones uniformly. Similar strategy has been adopted by Gutiérrez (2001), and Bruinsma and Rietveld (1998) in their works on accessibility evaluations.

3. Data Collection

It is expected that RUC might be launched in California by 2019 or later. Thus, our research is best suited for demonstrating accessibility impacts for the proposed RUC for the time immediately before and right after its implementation in 2019 (when, at this point, the travel dynamics of motorists would just begin to change). The data collection exercise has been classified into three categories as described below:

3.1. Employment data for counties

Employment data are collected *for m*anufacturing from counties of California for the year 2015 and year 2019. The data are collected using the OnTheMap web portal of the U.S. Census Bureau (OnTheMap, 2016). The demand data for year 2019 extrapolated based on data from five-year data from 2010 to 2015. The employment data obtained for year 2019 is corroborated with the employment projection of some counties in California from 2016-2040 Regional Transportation Plan/ Sustainable Communities Strategy (SCAG, 2018). The charts in Fig. *1* and Fig. *2* show respective employment for rural and urban counties of California for the years 2012 to 2015 for the Manufacturing industry sector. The employment data values seem to be very close to each other, indicating that these numbers would not vary significantly when compared to a future two or three year more employment data for most counties. Only the employment data designated as Work Area Characteristics (WAC) are used for the potential accessibility calculations. WAC indicates that the zones identified for employment data are places of work.

3.2. Travel demand data

Travel demand data for each of the counties for the workers employed in the five industry sectors were also collected from OnTheMap. The data were collected for years 2012, 2013 and 2014 based on their availability and contained information on number of workers who travelled within a given threshold distance divided into four categories: number of workers within 10 miles, number of workers between 10 to 24 miles, number of workers between 25 to 50 miles, and number of workers greater than 50 miles distance.

Further, an estimate of the value of decay parameter *α* is made for the impedance expression of Eq. (3). Most researchers adopt a value of *α* equal to 1 when travel-demand data are unavailable or difficult to obtain (Gutiérrez, 2001; Linneker and Spence, 1992). However, a true estimate of α is necessary to understand the commuter travel patterns correctly and to draw conclusions for further evaluation of accessibility (Chandra et al., 2013). In this paper, we had the advantage of computing the impedance decay parameter, α, using the threshold travel distance for both the 'without-RUC' (2014) and the 'with-RUC' (2019) scenarios. The traditional process of estimating α (for both rural and urban counties) consists of three main steps that we adopted in this study:

Step 1: Obtain the number of workers and associated travel distance.

Step 2: Plot percentage of number of workers versus potential travel distance threshold to determine if the trend in the variations is linear or exponential.

Step 3: If the trend is linear, the slope of the line would give α; otherwise, if the trend is exponential, convert distance and percentage workers to corresponding logarithms and obtain the slope, which is α. The assumption in the latter case is that the worker percentage varies exponentially with distance threshold, and converting the corresponding logarithmic values makes the variation linear, for which the slope of the plot gives the decay parameter α.

For 2012 till 2015, we observed that the percentage of jobs for majority of the counties decreased almost exponentially with respect to distance threshold. A large number of employment numbers of a county occurred from those that were within 10 miles of threshold distance as evident, with fewer jobs from geographically remote ones. This indicated that the trend of the plot between percentage number of workers versus threshold distances was more exponential than linear.

Based on the discussion above, we found the value of α to be approximately equal to 0.14 for rural and 0.11 for urban counties of California for the three years 2012, 2013 and 2014. Thus, this value of decay parameter was also assumed for the year 2019 – as it is assumed that the employment numbers within a given threshold distance might not change significantly with the increase in the number of years.

The price for gasoline, CNG, electric, and diesel for California (denoted by parameter α, in Eq. (4)) were obtained from the U.S Energy Information Administration (EIA, 2018) and compiled in Table 1. The fuel price for gas was obtained for the year 2013, however the price for CNG and the price for the year 2019 was retrieved using extrapolation on 2012-2018 data. The data for ω_f is obtained for average mileage across more than 10 vehicles of make year 2013. For the year 2019, the value of ω_f was extrapolated based on the average mileage data from four previous years 2015 to 2018. The road user charge, λ_j, was assumed to be 1.7 cents per mile, which is same as that in Oregon.

Table 1: Parameter values used for potential accessibility calculations

Parameter	Year 2013				Year 2019			
	Gasoline	**CNG**	**Electric**	**Diesel**	**Gasoline**	**CNG**	**Electric**	**Diesel**
$\lambda_{j,t}$ (RUC, cents per mile) (OreGO, 2018)	-	-	-	-	1.7	1.7	1.7	1.7
$\beta_{f,j,t}$ (price of fuel - \$/gallon) (EIA, 2018)	2.1	4	3.4	4.1	4	2.1	3.8	0.8
$\omega_{f,t}$ (average mileage miles/gallon) (US Department of Energy, 2018)	38	19	98	34	42	25	120	37

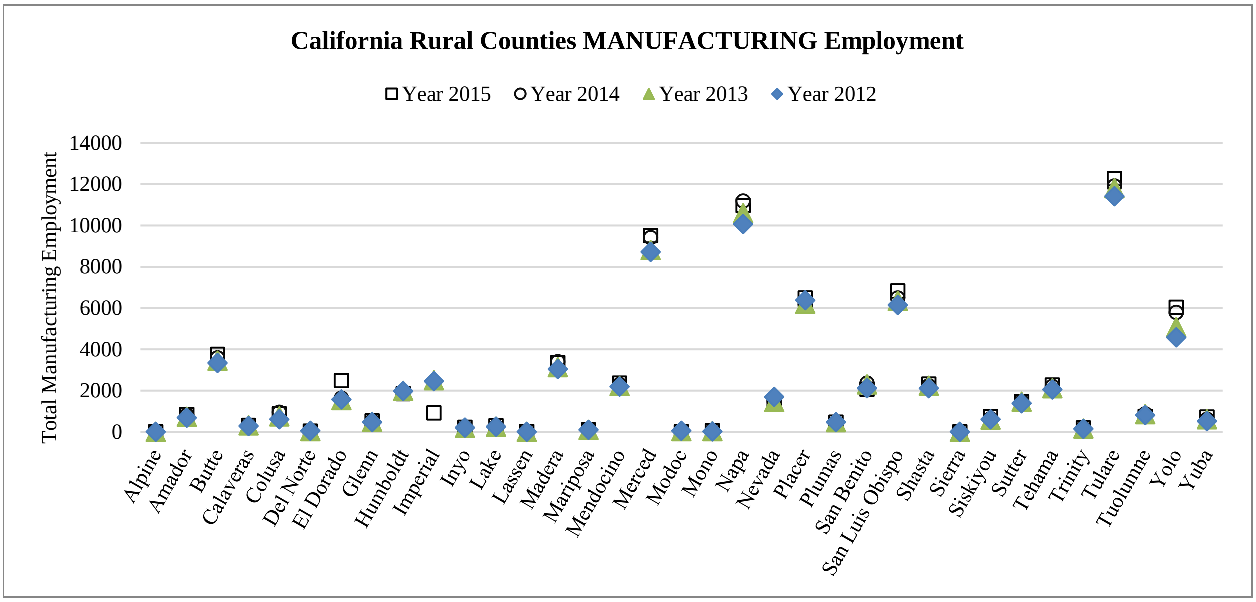

Fig. 1. Four-year Manufacturing employment across Rural counties of California

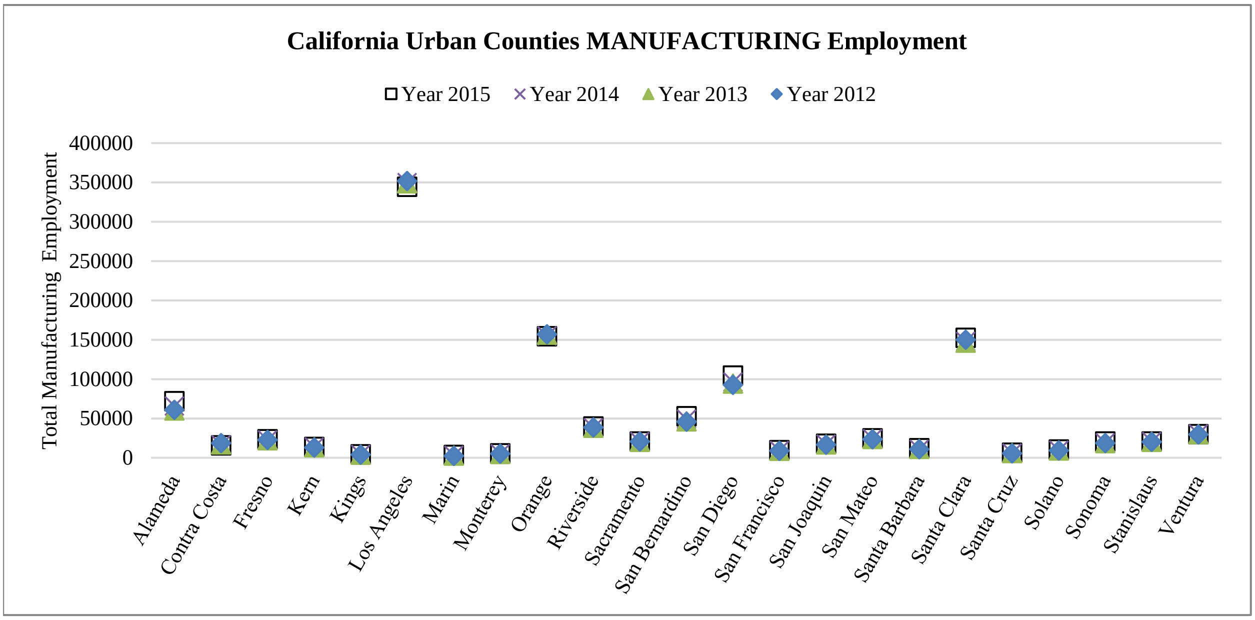

Fig. 2. Four-year Manufacturing employment across Urban counties of California

4. Results

The percentage change in potential accessibility is calculated for the rural and urban counties. The counties that are within threshold distance of travel from an origin county centroid are considered for calculating the percentage change. In this research, the threshold distances assumed are 30 miles, 20 miles and 10 miles.

4.1. Rural Counties

From the box-plots of Fig. 4, for the 30-mile threshold for the manufacturing sector, the percentage change in potential accessibility for three rural counties is significantly high for the four fuel types of gasoline, CNG, electric and diesel analyzed. These rural counties are found to be El Dorado, Mono and Colusa. The highest change in potential accessibility is observed to be the highest for the diesel fuel type for the 30-mile threshold. There is only one county of Del Norte that has a significantly low negative percentage change in potential accessibility for the 30-mile threshold across the four fuel types.

While most of the rural counties experience a positive change in potential accessibility for the 20-mile threshold, the two rural counties of Del Norte and Nevada have a negative percentage change for the three fuel types of gasoline and CNG. There are five more counties besides Del Norte and Nevada which have negative percentage change in potential accessibility for the 20-mile threshold for the electric fuel type. For the diesel fuel type, only the county of Nevada has a negative percentage potential accessibility change for the 20-mile threshold.

There is no rural county with negative percentage change in potential accessibility for any fuel type for the 10-mile threshold. For rural counties, significant increase in potential accessibility change from 2013 to 2019 are noted mainly for the 30-mile threshold in comparison to the 20-mile and 10-mile thresholds. The average change in potential accessibility for the rural counties and urban counties with the 20-mile threshold, is found to be approximately the same.

4.2. Urban Counties

The average percentage change in potential accessibility for urban counties is the highest for the diesel fuel type for the 30-mile threshold. There are several urban counties that have a negative percentage change in potential accessibility for the electric fuel type for the 30-mile threshold, out of which Orange County has the lowest negative percentage change.

The urban county of Marin is the only county with significantly very high positive percentage potential accessibility change for the 20-mile threshold commuting with gasoline and CNG fuel types – as noted in Fig. 4 for the manufacturing sector. Among several urban counties, the county of Contra Costa has the lowest percentage change in potential accessibility across the four fuel types, with the value being negative for electric fuel type.

The intra-county commute distance is less than 10 miles only for the county of San Francisco and thus, the urban county of San Francisco is the only county in California with a positive percentage change in potential accessibility for the 10-mile threshold commuting across the four fuel types - gasoline, CNG, electric and diesel.

In general, it is noted from the box plots of Fig. 4 that the average change in potential accessibility for manufacturing is found to be higher for the rural counties when compared with the urban counties and with other three fuel types.

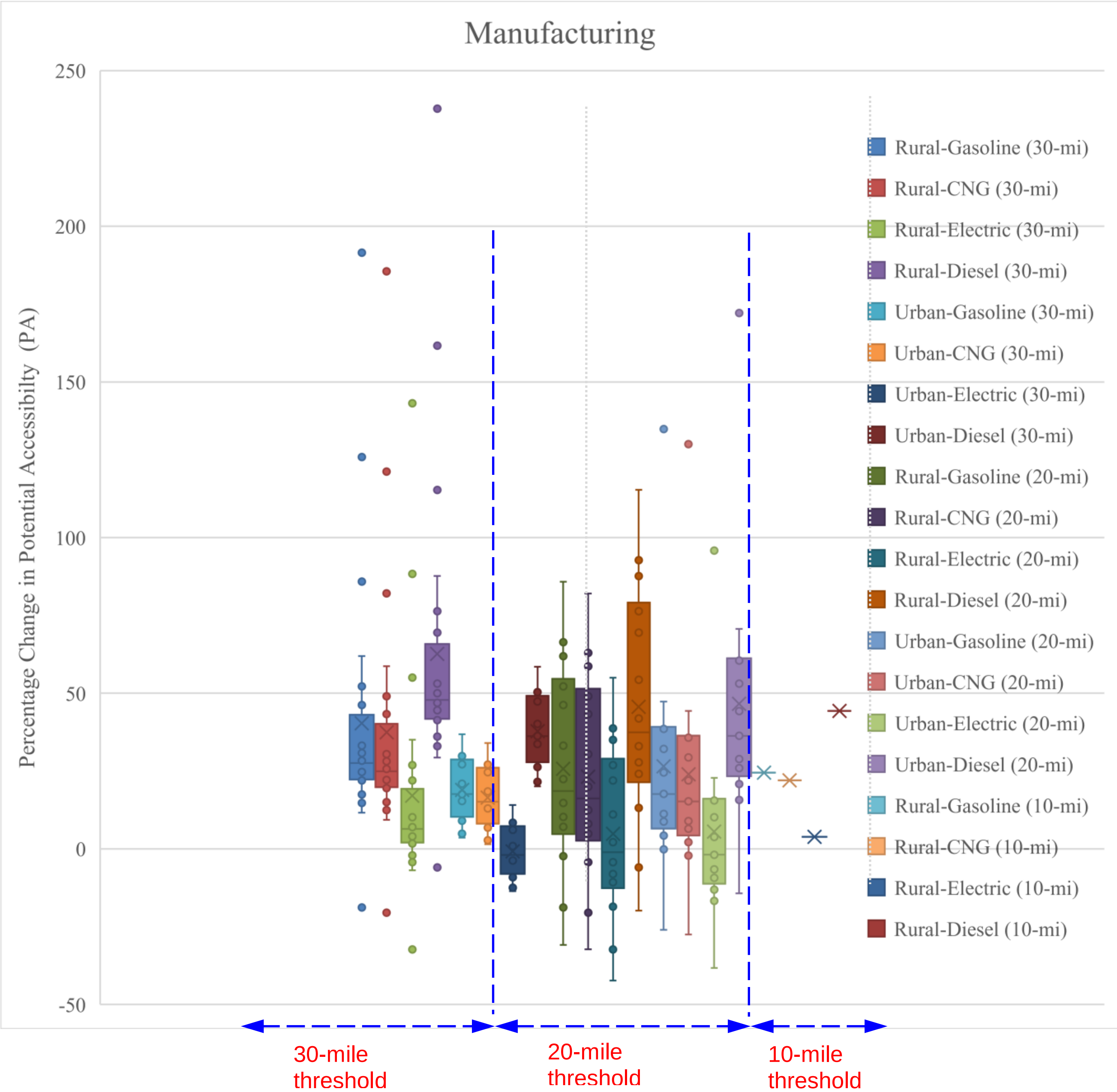

Fig. 4. Percentage change in potential accessibility (from 2013 to 2019) for Manufacturing sector

5. Concluding Remarks

In this paper, the underlying impacts of a future RUC implementation on accessibility for counties of California are investigated, particularly, with drivers operating vehicles of various fuel types – gasoline, electric, diesel and CNG. The analysis period spans from 2013 to 2019. The assumption is that RUC comes into effect in California in the year 2019 or later and designated as the year of 'with RUC' implementation, while the year 2013 serves as the base year 'without RUC' implementation.

This research adds to the knowledge of accessibility changes resulting in pros and cons of RUC implementation in California, especially in the context of industry-specific economic dependency (by employment) for the impacted counties. The exploration is carried out for manufacturing industry sector and suggestions can be made to improve attractiveness and agglomeration potential from the perspective of RUC implementation in California.

The average percentage change in potential accessibility for counties (whether rural or urban) from 2013 to 2019 for the manufacturing sector are found to be higher for the 30-mile threshold as compared to the 20-mile threshold, across all four fuel-type vehicles that can be used for commuting. This is due to an inclusion of an increased number of counties within the 30-mile threshold than for the 20-mile threshold. In general, it is also noted that for each fuel type, and for all three thresholds, the rural counties have a higher value of average potential change compared to the urban counties.

This exploratory analysis, we believe, could encourage some proactive public policy decisions for deciding RUC fee or even transportation network improvement, especially with respect to highway infrastructure, for other similar regions in the United States contemplating on implementing road user charge.

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