THE DIFFUSION OF ELECTRIC VEHICLES IN ILLINOIS: A PANEL STUDY OF THE IMPACT OF CHARGING INFRASTRUCTURE ON EV REGISTRATIONS

ALLEN P. ADOMITE, UNIVERSITY OF ILLINOIS SPRINGFIELD

The adoption of electric vehicles (EV) by citizens — and the subsequent governmental investment in public charging locations — is a timely public policy topic for Illinois state and local leaders. A causal connection between the two is rooted in two theories: observability within technological diffusion and range anxiety within psychological perceived risk. A panel regression estimating the impact of public charging locations on EV registrations demonstrates a positive causal result, with more than four additional EV registrations per 10,000 driving-age residents tied to each additional charging location within Illinois zip code areas between 2018 and 2022. Public policy implications regarding future state and local partnership and grant programs are discussed.

INTRODUCTION

Growth in electric vehicle (EV) ownership and EV charging is currently a top policy initiative for both the State of Illinois and the U.S. Department of Transportation. To aid in that commitment, Illinois Governor JB Pritzker signed a law creating the Reimagining Electric Vehicles (REV) program in November 2021, which — among several incentivization programs — seeks to increase the installation of public EV charging stations to encourage the growth of an EV ecosystem within the state (Illinois Department of Commerce & Economic Opportunity, n.d.). In February 2022, Governor Pritzker joined U.S. Secretary of Transportation Pete Buttigieg in announcing billions of dollars in a new EV charging infrastructure investment, stating: "The REV Act [is] focused on electric vehicles and we are making it easier for people to acquire an electric vehicle and to find a charging station across the state" (Hensel, 2022).

The federal government is providing $2.5 billion over the next five years to state and local governments for the implementation of community EV charging and the creation of alternative fuel corridors through the Bipartisan Infrastructure Law (Illinois Department of Transportation (IDOT), 2023). As part of the state deployment of these funds, IDOT has established a goal of placing one million electric passenger vehicles on Illinois roads by 2030 through the placement of public charging infrastructure every 50 miles within the designated alternative fuel corridors (IDOT, 2022, pp. 4-5). The first grant opportunity closed in June 2023 for federal funding covering up to 80% of the total project costs and up to $15 million for local municipalities, townships, and metropolitan planning organizations.

As mayor in 2020, I helped create the first public EV charging station in my community of Troy, Illinois. With a public-private partnership that included use of the city's tourism money, infrastructure provided by the local electric cooperative, and parking spaces provided by a local hotel, the chargers were an investment to spur local visits from travelers along our exit on Interstates 55 and 70 (Richardson, 2020). The goal of this project was twofold: By placing a charging location near the interstate, our municipality was hoping to increase observability of available charging to passing EV motorists to encourage visits to our community while also increasing visibility to encourage local citizens to adopt EV technology.

This example from my community poses a critical question about the federal-state-local partnership in providing federal funds through state transportation agencies to local governments for the construction of EV charging locations: Does the creation of new charging stations influence the private ownership of EVs? As local leaders are asked to pledge at least 20% of the cost of expanding EV charging locations, the answer to this research question can be informed by European research from Germany and Norway (Illmann & Kluge, 2020; Schulz & Rode, 2022), as well as meta-analyses on consumer demand obstacles for EVs (Li, Long, et al., 2017; Singh et al., 2020).

In this study, we explore the theoretical justification of why an increase in EV charging might influence an increase in EV ownership through two conceptual frameworks: a theory of observability within technological diffusion and a theory of range anxiety within psychological perceived risk. Using data on the number of EV charging locations, the charging power of those locations, and the number of EVs registered within individual Illinois zip code areas from 2018 to 2022, we employ two panel data models to test hypotheses on each theory. The results help to inform federal, state, and local leaders on the efficacy of the investment in EV charging to encourage EV ownership.

RESEARCH CONTEXT

The obstacles to consumer EV adoption are varied in nature and stem from a variety of differing policy theories. For example, Li, Tong, et al. (2017) categorize potential barriers, including "high purchase cost, limited driving range, the lack of charging infrastructure, and long charging time" (p. 90). Policy incentives for EV adoption range from price incentives, such as rebates and tax credits, to better parking and access to high-occupancy vehicle lanes. The key policy goal of charging infrastructure grants, however, is twofold: addressing the issue of "range and inconvenience barriers" and "increasing visibility and general awareness of the [EV] technology" (Slowik & Lutsey, 2017, p. 6).

The underlying theories supporting these policy initiatives, as opposed to the more conventional economic theories on direct consumer price incentives, are well supported in literature. Two major meta-analyses covering overlapping time periods from 2011-2019 started with initial pools of nearly 3,200 and 1,850 articles, narrowing reviews to 211 and 40 articles for summarization respectively (Li, Long, et al., 2017; Singh et al., 2020). While technological diffusion and range anxiety theories were both deductively identified in these analyses, several studies have inductively arrived at an association between public charging infrastructure and EV ownership as well (Bailey et al., 2015; Illmann & Kluge, 2020; Noel et al., 2019).

In a meta-analysis of 40 peer-reviewed studies published between 2011 and 2016, Li, Long, et al. (2017) categorized three factors influencing consumer purchases of EVs, including demographic, situational, and psychological factors. According to the authors, demographic factors include a focus on income, educational attainment, and family size while situational factors focus on technical features such as driving range, charging times, cost dynamics, incentives, and carbon-reduction performance. Finally, psychological factors focus on consumer attributes such as experience, attitudes, emotions, societal influences, and symbology. In the analysis, range anxiety is classified as a technical feature within situational factors, and technological diffusion is included within the societal influences of psychological factors.

In a wider analysis, Singh et al. (2020) arrived at nearly identical classifications (demographic, situational, psychological) while splitting governmental incentives and charging infrastructure into a fourth factor labeled as contextual. Within this analysis, range anxiety is derived from both contextual (charging infrastructure) and psychological (perceived risk) factors while technological diffusion is derived from situational factors. Regardless of the classifications, both theories are prominently mentioned in each analysis.

Noel et al. (2019) define range anxiety as "the psychological anxiety a consumer experiences in response to the limited range of an electric vehicle" and impresses that it continues "as one of the most pressing barriers to [EV's] mainstream diffusion" (p. 96). The authors continue in their assessment with an assumption that a reasonable amount of public charging infrastructure decreases range anxiety. In their survey of Scandinavians, Noel et al. (2019) determined that the limited range of charging infrastructure constituted the largest barrier and the lack of it the third largest barrier to EV adoption, with only overall vehicle cost rating near those factors.

Alternatively, a theory of technological diffusion (also often called diffusion of innovation theory) is defined as a broad economic theory of consumer adoption that includes, among five factors, the observability of new technologies and innovation. Developed by Rogers (1962), observability within technological diffusion is defined as "the degree to which the results of an innovation are visible to others" (Rogers & Murcott, 1995, p. 245). Under this theory, an innovation's observability — as socially perceived — is positively associated with the innovation's adoption.

Bailey et al. (2015) used observability as the hypothesis of their survey of Canadians regarding public EV charging infrastructure. While the authors identified that 18% of early EV buyers were previously aware of a public charging point, the study found no significant relationship when adding control variables. The authors directly tested both "existence" and "abundance," which tests whether higher levels of charging influence the model. Subsequently, two additional studies have directly examined causality between public charging infrastructure and EV ownership, also using the location versus abundance models employed by Bailey et al. (2015). In Germany, Illmann & Kluge (2020) spatially examined causality between the quantity, capacity, and abundance of EV charging, finding that consumers have a greater response to the charging speeds available from EV charger abundance. Similarly, Schulz & Rode (2022) found that public charging infrastructure stimulated EV ownership in Norway in their 10-year study period.

The association between public charging locations and quarterly EV sales in 353 U.S. metro areas was statistically significant in a model employed by Li, Tong, et al. (2017). However, the authors' model examined the causal effect of EV ownership on a profit model of public charging infrastructure growth, which is a reversal of the causal relationship identified in the German and Norwegian studies. Additional research has considered whether the lack of EV charging infrastructure was a barrier to EV adoption in Thailand (Kongklaew et al., 2021) or was spatially equitable in China (Li et al., 2022).

Alternatively, two studies found no causal connection between public charging infrastructure and EV diffusion. Mukherjee & Ryan (2020) examined the factors influencing EV adoption in Ireland but were unable to establish a relationship between early adopters and public charging infrastructure. Likewise, Ou et al. (2020) were unable to establish a connection between the same variables in China.

In summary, two theories of observability within technological diffusion and range anxiety within psychological perceived risk plausibly describe the correlation between the growth of EV charging infrastructure and of private EV ownership. Previous studies have factored in both the existence of public charging locations (termed as "locations") as well as the charging power available at those locations (termed as "abundance"). This study seeks to replicate the German (Illmann & Kluge, 2020) and Norwegian (Schulz & Rode, 2022) studies to test these theories on the association between public charging infrastructure and EV ownership in Illinois.

DATA AND METHODOLOGY

This study tests two hypotheses that are operationalized into two panel data models. To explore the theory of observability, an increase in individual EV charging locations would need to demonstrate a correlation with increased EV ownership. This hypothesis is tested in the Locations Model of panel data (see Table 1). A theory of range anxiety requires potential EV owners to understand more than just proximity to an EV charging location. Due to the lengthier time commitments between EV charging and traditional gas-powered vehicle fueling, testing the theoretical effect of range anxiety requires considering the electrical charging capacity of EV charging locations. Illmann & Kluge (2020) label this as an "abundance model."

TABLE 1

RESULTS OF TWO PANEL REGRESSION MODELS (LOCATION AND ABUNDANCE) OF POPULATION-ADJUSTED EV REGISTRATIONS AND EV CHARGING INFRASTRUCTURE

FIXED EFFECTS PANEL REGRESSION				
Dependent Variable: EV Registrations/10K	**Locations Model n = 1,334 t = min 1, max 4**			
VARIABLE	**COEFFICIENT**	**Z**	**P-VALUE**	
Constant	45.4092	3.857	0.001	***
Locations	4.1808	4.370	0.001	***
Locations -1 (Lag)	5.8255	3.878	0.001	***
Abundance				
Abundance -1 (Lag)				
Gender	-0.0112	-0.093	0.926	
Race	-0.6557	-5.609	0.001	***
Ethnicity	0.0818	0.490	0.624	
HH Median Income	0.0003	6.494	0.001	***
Educational Attainment	0.0492	0.056	0.956	
R-Squared	0.905916			
Within R-Squared	0.261006			

**** Suitability tests for fixed-effects panel regression such as cross-sectional dependence (Pesaran CD test), named aggressors, differing group intercepts, Hausman test for inconsistent GLS estimation, and correlation between the regressors and their unique errors (Breusch-Pagan test) all indicated the fixed-effects model was superior to random effects or pooled OLS regression. HAC robust standard errors were used to correct for autocorrelation and heteroskedasticity.*

Therefore, the Location Model hypothesis here tests whether EV charging locations within a geographical unit correlate with increased EV ownership within the same geographical unit. The Abundance Model hypothesis here tests whether the greater average charging capacity of EV charging locations within a geographical unit correlates with increased EV ownership. Correlation within the first hypothesis indicates influence of observability theory, and correlation within the latter model indicates the influence of range anxiety theory.

FIXED EFFECTS PANEL REGRESSION				
Dependent Variable: EV Registrations/10K	**Abundance Model n = 1,359 t = 4**			
VARIABLE	**COEFFICIENT**	**Z**	**P-VALUE**	
Constant	54.7029	4.234	0.001	***
Locations				
Locations -1 (Lag)				
Abundance	0.0231	1.945	0.052	
Abundance -1 (Lag)	0.0651	4.166	0.001	***
Gender	0.0185	0.151	0.880	
Race	-0.8103	-6.204	0.001	***
Ethnicity	0.0615	0.361	0.718	
HH Median Income	0.0004	7.208	0.001	***
Educational Attainment	0.023182	0.517	0.605	
R-Squared	0.890334			
Within R-Squared	0.138615			

Both models use secondary data sources from the U.S. Department of Energy (DOE), the Illinois Secretary of State, and the U.S. Census Bureau for quantitative panel regression. The independent variable of interest for the Location Model is public charging locations in Illinois, and the variable of interest for the Abundance Model is the total amount of the electrical charging capacity. The dependent variable of interest is EV vehicles registered in Illinois. The time period of interest is the overlap of the data sets: a five-year period between January 2018 and January 2022, with annual data for each that reflects the variable counts on January 15 of the corresponding year (Illinois Secretary of State, 2022). The cross-sectional units are geographical zip code areas in Illinois.

Public charging infrastructure for the United States and Canada is tracked and provided to the public by the Alternative Fuels Data Center (AFDC) of the DOE. As of July 2023, approximately 58,000 public charging sites were listed within the data set, including 1,166 in Illinois (AFDC, 2022). For the purposes of this study, Illinois-based public charging sites were grouped by their year of installation and totaled by zip code area for the period between January 2018 and January 2022. The database includes 244 existing charging locations active on January 15, 2018. According to the AFDC database, the first registered charging location in Illinois went online in June 2010 at the City of Alton's municipal building.

While charging infrastructure growth experienced 28% and 23% annual gains in 2018 and 2019 respectively, subsequent gains in 2020 and 2021 brought the January 15, 2022, total to 782 public charging locations — more than triple the locations from four years earlier. However, when compared with EV registrations, the growth rate of public charging fell far below the growth of vehicle registrations. The comparison fails to consider gains in home charging, but each public charging location served 34.5 EVs in January 2018, and this ratio grew to more than 48 EVs per charger by January 2022.

While the overall number of locations is an important measure of public charging infrastructure, EV drivers generally have three choices in the level of charging, which can directly affect the time needed to reenergize the EV battery. Previous studies, such as the German one by Illmann & Kluge (2020), refer to the number of kilowatts (kW) provided as charging capacity and the average number of kW per location as charging abundance. For drivers, the terminology separates charging into three levels, numbered from the least amount of energy (Level 1) to the most (Level 3).

Level 1 charging is described as plugging the car into a standard 120V outlet, such as the typical outlet in your home. Similar 120V electrical outlet delivery can be found outside almost any commercial or residential building. However, Level 1 charging is generally not considered in studies on public charging infrastructure due to its almost universal availability and nearly ineffective energy delivery. The time required to fully charge an EV car battery with 250 miles of range with Level 1 charging might take up to 40 hours (ChargeHub, n.d.).

Level 2 charging provides double the amount of energy at 240V and allows for three to seven times faster charging. The Level 2 chargers can fill an EV car battery with 250 miles of range in approximately six hours. For the purposes of this evaluation and for inclusion in the AFDC database, a public charging location needs at least Level 2 charging. It's important to note that Level 1 and Level 2 charging both use alternating current (AC) to deliver energy to the vehicle (ChargeHub, n.d.).

Level 3 charging is unique in that it uses direct current (DC) for EV battery charging rather than AC, which is why these chargers are often referred to as "DC fast chargers." The amount of power delivered in Level 3 chargers is exponentially greater and can deliver 250 miles of range to an EV battery in less than 60 minutes, but the compatibility of charging equipment varies more for Level 3 charging (ChargeHub, n.d.). For example, Tesla has a proprietary network of "destination" Level 3 charging that is not compatible with other EVs, so while Tesla EVs can charge at non-Tesla Level 2 chargers, they cannot charge at non-Tesla Level 3 chargers.

In their analysis of German public charging infrastructure, Illmann & Kluge (2020) quantitatively tested both location models and abundance models, finding statistically significant results for both measures. This study is similarly testing each measure of public charging in separate models to determine association with the dependent variable. The same kW estimate used by Illmann & Kluge (2020) is used here: 22kW of energy for a Level 2 charger and 50kW of energy for a Level 3 charger (p. 4). To determine charging abundance within a zip code area, the total capacity (overall kW) is divided by the number of locations to determine an average kW capacity per location within the zip code area.

This study uses data for Illinois EV registrations from publicly available data from the Illinois Secretary of State's Office. The agency provides monthly data by both county and zip code reported as of the 15th day of each month, dating back to November 2017. To increase cross-sectional units and adjust for monthly variations in registration data, zip code area and annual time-period data was chosen for this quantitative analysis. Using annual data for EV registrations also allowed for the inclusion of annual census data in the panel analysis. To balance EVs by population, the rate of EVs per 10,000 in driving-age population was calculated for each zip code area for each time period.

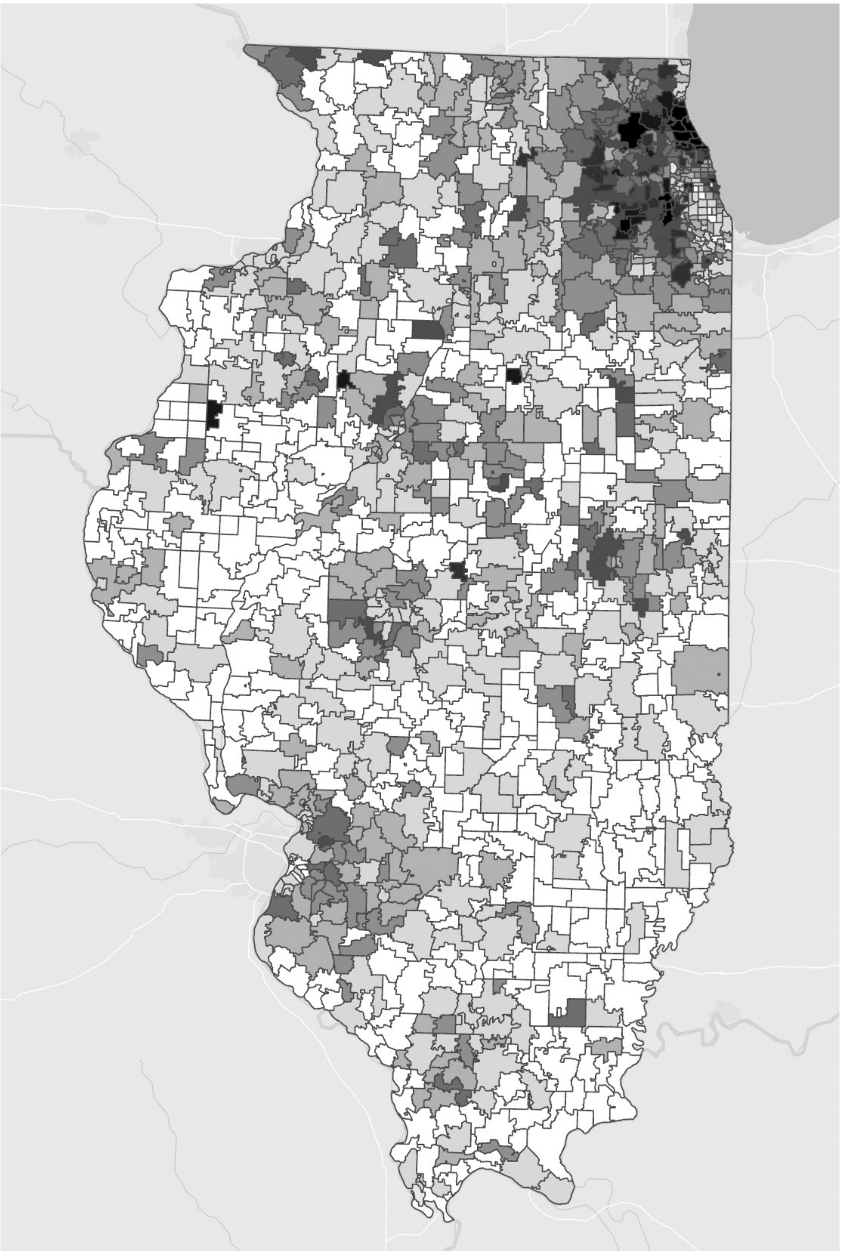
The choice of zip code areas for cross-sectional analysis is not ideal, but it is superior to the more limited delineation by county. Geographic researchers often caution against the use of zip code areas in geospatial analysis, with one prominent researcher adding, "There is little doubt that the U.S. zip code is one of the quirkier 'geographies' in the world" (Grubesic, 2008, p. 129). Criticisms, such as several suggested by Forrest (2019), warn that zip codes fail to represent real geographic boundaries because the area within is generated from linear postal routes and that zip code areas hold little representation to how actual humans behave. Despite these general flaws, zip code areas are more compatible with municipal areas than county boundaries, so their use can provide more informative models for local municipal government decision making.

EV registrations grew steadily over the study period, with 8,435 EVs registered in Illinois in January 2018 and 37,723 in January 2022, an increase of nearly 350% over a four-year period. Of note, Illinois also provides separate statistics for flex fuel and hybrid vehicles. This distinction is visible on Illinois roadways as EVs display a license plate with numerical numbers followed by the letters "EV," and as of January 2020, EV owners pay an additional $100 per year in vehicle registration fees to compensate for the lack of motor fuel taxes garnered from the vehicles (Illinois Secretary of State, n.d.). To verify that the vehicle is all-electric, registrants must sign an affirmation with the Secretary of State.

As previously mentioned, the cross-sectional unit of zip code area allowed for greater geographic diversity over the alternative Illinois county unit, garnering 1,359 geographical units over 102 county units. Additionally, federal census data from the 5-Year American Community Survey (ACS) is also available by zip code area, providing the opportunity to introduce additional explanatory variables to the panel study. Integrating the zip code area data from the EV registrations data, public charging location data, census data, and an ArcGIS zip code area shapefile required consolidation of certain data points for a clean analysis. For example, fewer than 50 overall EV registrations were moved from zip code area designations into a larger pool of EV registrations not attributed to zip code areas by the Secretary of State's Office to match data. For visual analysis, the U.S. zip code areas shapefile from Esri for ArcGIS was used and is displayed in Figure 1.

FIGURE 1

MAP OF POPULATION-ADJUSTED EV REGISTRATION BY ILLINOIS ZIP CODE AREA IN JANUARY 2022



Note: Darker shades indicate a greater level of population-adjusted EV ownership

Demographic census data for gender, race, ethnicity, household income, and educational attainment were added to the panel regression as control variables. Covariance between independent variables was tested using a correlation matrix to identify any potential multicollinearity problems in the panel regression. No variables were excluded from the analysis. Panel data regression provides a combination of analysis of cross-sectional units over multiple time periods, allowing for the control of bias from unobserved variables not included in the equation. Using the quantitative statistical program Gretl, the independent variables of interest — charging locations and charging abundance — were tested against the dependent variable of EV registrations per 10,000 people in the population who are of driving age, controlling for gender, race, ethnicity, household income, and educational attainment. Control variables are consistent with variables used in similar studies conducted in Norway (Schulz & Rode, 2022) and Thailand (Kongklaew et al., 2021). Some variables from previous studies, such as political trends and driving experience, were not available for Illinois zip code areas.

RESULTS AND ANALYSIS

Two fixed-effects panel models found differing results for the question of whether public charging infrastructure influences the registration of EVs in Illinois. In the Locations Model, a positive statistically significant result was obtained, controlling for race and household median income. In the Abundance Model, the results were not statistically significant, although variables for race and household median income continued to be statistically significant.

Therefore, the results are mixed regarding the research question of whether the growth of public charging infrastructure for EVs affects the private ownership of EVs. The Locations Model indicates that each additional charging location within an Illinois zip code area produces a statistically significant result of 4.18 additional EV registrations per 10,000 driving-age residents over the mean average of 12.84 population-adjusted EV registrations. The results support a theory of observability within technological diffusion but do not support a theory of range anxiety within psychological perceived risk.

Two control variables also exhibit statistical significance within both panel regression models. Race, which is operationalized as the portion of white residents within each zip code area, is negatively associated with EV ownership. This result suggests that the greater racial diversity within a zip code area, the greater the amount of EV ownership. Similarly, EV ownership correlated with higher household incomes within zip code areas. These two results together suggest future research on EV ownership warrants consideration of political variables within the regression equation, with the goal of increasing the relatively low explanatory powers displayed in these models (within R-squared totals of 0.261 and 0.139, respectively). Again, previous authors (Li, Long, et al., 2017; Singh et al., 2020) suggested a range of additional factors — demographic, situation, contextual, and psychological — that could influence the growth of EV registrations.

Finally, the statistically significant lag variable for EV charging locations, which is statistically significant in the Locations Model, helps to control endogenous biases due to simultaneity or reversed causality. In the Locations Model, causality concerns arise from the potential effects the dependent variable of increased EV ownership can exert on the market for new EV charging locations. These estimation biases can be remedied using a lagged independent variable (Zaefarian et al., 2017). In this case, the significance of the one-year lag of the independent variable charging locations suggests the bias of past EV purchases does not affect the current purchases, eliminating the problem of reverse causality.

CONCLUSION

The results of the Locations Model in this analysis strongly suggest that governmental investment in public charging infrastructure — specifically aimed at increasing the number and visibility of public charging locations — can meaningfully impact the growth and adoption of EVs by Illinois drivers. While the results are inconclusive regarding the Abundance Model, the panel estimation in this study clearly indicates that more public charging locations within an Illinois zip code area positively affects the number of EV registrations.

Currently, federal and state lawmakers have prioritized charging infrastructure for greater investment in the next five years. This study not only contributes greater knowledge to how public charging infrastructure affects the adoption of EVs by Illinois drivers, but it confirms that the strategy employed by Illinois governmental leaders to increase EV registrations and ownership has a higher opportunity for success. Local government leaders interested in increasing the adoption of EVs within their own communities have an incredible opportunity to partner with federal and state government to fund public charging infrastructure through grant program opportunities such as the Federal Highway Administration's charging and fueling infrastructure discretionary grant program (Federal Highway Administration, 2023).

However, this analysis also provides timely conclusions within a cutting-edge policy topic. State and local governments are making major investments to persuade citizens to adopt EV technology. This Illinois-focused study contributes fresh data to support state policymaking regarding public charging infrastructure, but it also adds to similar research, such as Neves et al. (2019), which concluded, "The penetration of EV [technology] is dependent on improvements in charging infrastructure" (p. 37). In Illinois, the historical data clearly demonstrates that increases in public charging infrastructure can positively impact new EV registrations and that additional locations hold greater importance than increases in charging abundance.

Allen P. Adomite is a Doctoral Candidate in Public Administration (ABD) at the University of Illinois Springfield and a former Mayor (2013-2021) of the metro-east municipality of Troy, Illinois. Adomite is currently researching the local municipal policy diffusion of the Illinois Video Gaming Act for his dissertation. He holds an MPA from Southern Illinois Uuniversity Edwardsville and a Bachelor of Journalism from the University of Missouri. Adomite currently serves as Township Supervisor in Jarvis Township in Madison County.

REFERENCES

Alternative Fuels Data Center, United States Department of Energy. (2022). Electric vehicle charging stations. [Data set]. https://afdc.energy.gov/fuels/electricity_stations.html

Bailey, J., Miele, A., & Axsen, J. (2015, May). Is awareness of public charging associated with consumer interest in plug-in electric vehicles? *Transportation Research Part D: Transport and Environment*, 36, 1-9. https://doi.org/10.1016/j.trd.2015.02.001

ChargeHub. (n.d.). Guide on how to charge your electric car with charging stations. https://chargehub.com/en/electric-car-charging-guide.html

Federal Highway Administration. (2023, February 21). *Charging and fueling infrastructure discretionary grant program*. https://www.fhwa.dot.gov/environment/cfi/cfi_webinar_2023-2-21.pdf

Forrest, M. (2019, August 8). Stop using zip codes for geospatial analysis. Carto. https://carto.com/blog/zip-codes-spatial-analysis

Grubesic, T. H. (2008, June). Zip codes and spatial analysis: Problems and prospects. *Socio-Economic Planning Sciences*, 42(2), 129-149. https://doi.org/10.1016/j.seps.2006.09.001

Hensel, A. (2022, February 15). Pritzker touts Illinois' position in electric vehicle industry. The Center Square. https://www.thecentersquare.com/illinois/pritzker-touts-illinois-position-in-electric-vehicle-industry/article_9b1d825a-8e7a-11ec-bc90-bb5158b9ff2c.html

Illinois Department of Commerce & Economic Opportunity. (n.d.). Reimagining Energy and Vehicles (REV) Illinois Program. https://dceo.illinois.gov/businesshelp/rev.html

Illinois Department of Transportation. (2022, August 1). Illinois electric vehicle infrastructure deployment plan. https://idot.illinois.gov/content/dam/soi/en/web/idot/documents/transportation-system/planning/drive-electric/Illinois%20State%20Electric%20Vehicle%20Plan.pdf

Illinois Department of Transportation. (2023, March 24). Circular Letter 2023-11: 2023-2024 federal charging and fueling infrastructure discretionary grant program — notice of funding opportunity. https://legislative.iml.org/file.cfm?key=25556

Illinois Secretary of State. (2022). Electric vehicle counts by county. (January 2018 January 2022). [Data set]. https://www.ilsos.gov/departments/vehicles/statistics/electric/home.html

Illinois Secretary of State. (n.d.). Electric vehicle license plates guide. https://www.ilsos.gov/departments/vehicles/license_plate_guide/electric_vehicle.html

Illmann, U., & Kluge, J. (2020, September). Public charging infrastructure and the market diffusion of electric vehicles. *Transportation Research Part D: Transport and Environment*, 86(3), 1-17. http://dx.doi.org/10.1016/j.trd.2020.102413

Kongklaew, C., Phoungthong, K., Prabpayak, C., Chowdhury, M. S., Khan, I., Yuangyai, N., Yuangyai, C., & Techato, K. (2021, November). Barriers to electric vehicle adoption in Thailand. *Sustainability*, 13(22), 1-14. https://doi.org/10.3390/su132212839

Li, G., Luo, T., & Song, Y. (2022, January). Spatial equity analysis of urban public services for electric vehicle charging — implications of Chinese cities. *Sustainable Cities and Society*, 76, 1-13. https://doi.org/10.1016/j.scs.2021.103519

Li, S., Tong, L., Xing, J., & Zhou, Y. (2017, March). The market for electric vehicles: Indirect network effects and policy design. *Journal of the Association of Environmental and Resource Economists*, 4(1), 89-133. https://doi.org/10.1086/689702

Li, W., Long, R., Chen, H., & Geng, J. (2017, October). A review of factors influencing consumer intentions to adopt battery electric vehicles. *Renewable and Sustainable Energy Reviews*, 78, 318-328. https://doi.org/10.1016/j.rser.2017.04.076

Mukherjee, S. C., & Ryan, L. (2020, February). Factors influencing early battery electric vehicle adoption in Ireland. *Renewable and Sustainable Energy Reviews*, 118, 109504. https://doi.org/10.1016/j.rser.2019.109504

Neves, S. A., Marques, A. C., & Fuinhas, J. A. (2019, May). Technological progress and other factors behind the adoption of electric vehicles: Empirical evidence for EU countries. *Research in Transportation Economics*, 74, 28-39. https://doi.org/10.1016/j.retrec.2018.12.001

Noel, L., de Rubens, G. Z., Sovacool, B. K., & Kester, J. (2019, February). Fear and loathing of electric vehicles: The reactionary rhetoric of range anxiety. *Energy Research & Social Science*, 48, 96-107. https://doi.org/10.1016/j.erss.2018.10.001

Ou, S., Lin, Z., He, X., Przesmitzki, S., & Bouchard, J. (2020, April). Modeling charging infrastructure impact on the electric vehicle market in China. *Transportation Research Part D: Transport and Environment*, 81, 1-16. https://doi.org/10.1016/j.trd.2020.102248

Richardson, J. (2020, July). Troy story. *The Southwestern*, 72(7), 3. https://www.sweci.com/sites/sweci/files/Southwestern%20Magazine/PDFs/swjuly20.pdf

Rogers, E. M. (1962). *Diffusion of innovations*. The Free Press of Glencoe Division of The MacMillan Co. https://doi.org/10.1002/jps.2600520633

Rogers, E. M., & Murcott, S. (1995). Attributes of innovations and their rate of adoption. In *Diffusion of Innovations* (pp. 204-251). Free Press.

Schulz, F., & Rode, J. (2022, January). Public charging infrastructure and electric vehicles in Norway. *Energy Policy*, 160, 1-12. https://doi.org/10.1016/j.enpol.2021.112660

Singh, V., Singh, V., & Vaibhav, S. (2020, September). A review and simple meta-analysis of factors influencing adoption of electric vehicles. *Transportation Research Part D: Transport and Environment*, 86, 1-50. https://doi.org/10.1016/j.trd.2020.102436

Slowik, P., & Lutsey, N. P. (2017, July). *Expanding the electric vehicle market in U.S. cities.* International Council on Clean Transportation. http://dx.doi.org/10.13140/RG.2.2.35691.85289

Zaefarian, G., Kadile, V., Henneberg, S. C., & Leischnig, A. (2017, August). Endogeneity bias in marketing research: Problem, causes and remedies. *Industrial Marketing Management*, 65, 39-46. https://doi.org/10.1016/j.indmarman.2017.05.006