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Air Quality: Population Density and Transportation Emissions

Mathew Sterling

ABSTRACT: Air quality is still a major problem in much of the world. Greenhouse gases and other pollutants still continually make their way into our atmosphere. On a global scale these emissions contribute to climate change. On a local level they contribute to air pollution which contributes to heart and lung diseases.

This study looks at population density within the land-use of an area to determine if there is a negative correlation with transportation emissions. The goal of this study is to enrich our understanding of how we contribute to air pollution. My hypothesis predicted that population density leads to lower average driving distances which in turn improves air quality.

Background

Transportation is the fastest growing cause of GHG emissions and is set to soon become the economic sector with the highest percentage of total emissions and the number of passenger vehicles is increasing globally. (Sorrel, 2016) While some researchers focus on transportation or land-use, these researchers studied how both transportation and land-use policy affected air quality. Their research indicated the potential complexity for future planning. Transportation emissions were measured from different development patterns around the city when weather conditions were similar. "These differences in the magnitude of emissions produced greater changes in air quality than differences in regional development patterns between the four scenarios, although the effects of urbanization patterns were distinguishable." (McDonald-Buller, 2010, 28) This means that they found a greater change in emissions related to vehicle emissions from stricter federal law than that of the land-use pattern.

Many who research transportation emissions will focus on what directly emits the air pollution, such as personal vehicles, commercial trucks, and busses. The problem lies deeper than only the vehicle technology, but it is nonetheless an important part of the problem we face. While we are not yet all driving electric cars with one-hundred percent renewable electricity sources, there are changes that can be made immediately to improve GHG emissions. Some of these improvements fall on transit operators to implement. Many transit systems are not designed with fuel efficiency in mind. In fact, busses can be more energy intensive per person if ridership is not high enough. (Cheng, 2016) Most transit in American cities are

on average not efficient regarding fuel use or an individual rider getting from point A to point B. But this is where I think there is an underlying reason for such problems. It is important to ask why transit ridership is low. One of the most likely reasons that American cities have in common is because of the land-use pattern. If someone does not live and work in a dense area, he or she is unlikely to give up driving for a less convenient option.

Another way of evaluating transportation systems is to recognize the differences in how developing cities will handle transportation. Car ownership is on the rise across the developing world. Right now in most of these places, anything besides single occupancy vehicles are drastically better for air quality. This is because most areas are experiencing this change at an exponential rate, and the road infrastructure is not ready to handle it. Congestion becomes out of control as a result. For now any types of busses, even dirty ones with terrible emissions, are still a cleaner option because they are so much more efficient per person. (Bus, 2002) In these developing cities, there is an underlying land-use problem. With drastic population growth there is a drastic change in housing stock. It is easier to build out when overwhelmed with new people than it is to take the time to plan the right level of infrastructure to accommodate density.

Transportation emissions cannot be mitigated without addressing land-use policy. They are directly related. The proximity of destinations is essential to the logistics of transportation systems. The mitigation of GHG is mainly through reducing vehicle miles traveled. It is a less important but relevant factor that vehicles should be more

efficient, but this is after assuming it applies to people already living in denser neighborhoods. There is evidence that supports the idea that land-use policies are effective tools for reducing transportation emissions (Song, 2016).

The connection between transportation and land-use is recognized by many transit operators. Some such as Metro in Los Angeles, BART in San Francisco and VTA in San Jose are adopting housing policies to complement their transit efforts in order to lead their cities in sustainable efforts. (Rao, 2016) California is also examining the effect of land-use on transportation emissions by possibly changing the gas tax to vehicle miles tax. It is currently in a pilot program to measure if driving distance is better than gas usage (Dawid, 2016).

There is also the reverse thought that transportation policy affects land-use (Rauscher, 2014). Instead of planning for growth and sustainability this means retrofitting areas that may not be ready for the density or transportation. This can lead to wasted money and an underutilized transit system.

Methods

I analyzed the correlation between different measurable factors: how dense a population is, driving distances and air pollution. The object of study was counties of California. The most recent year that all factors had data for was 2010.

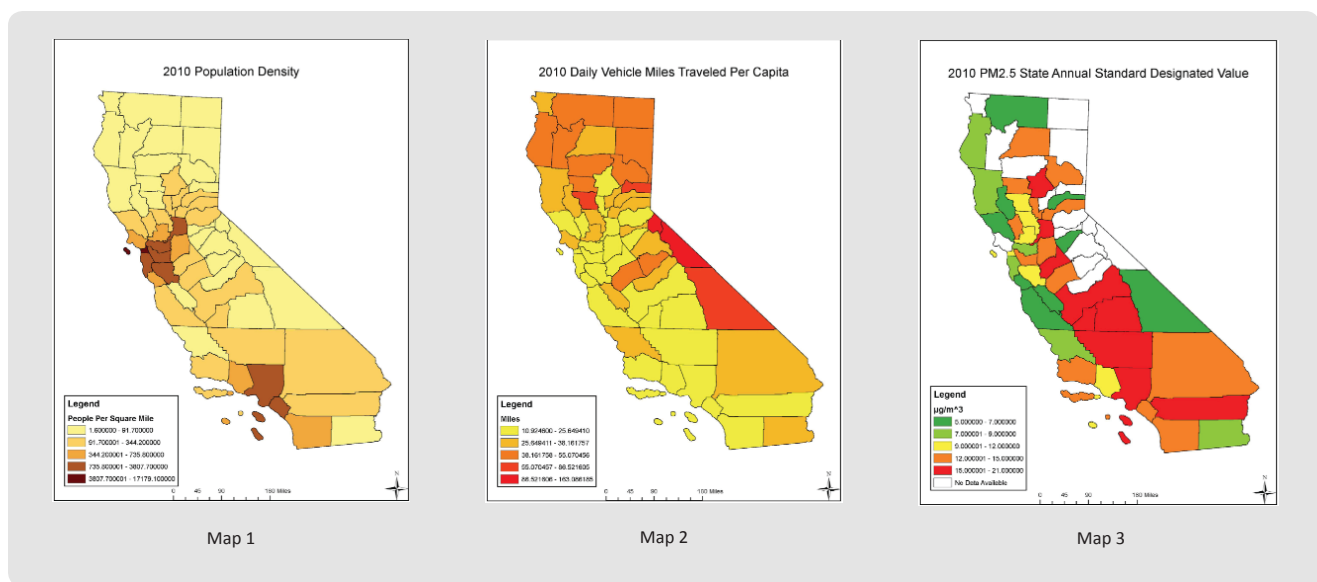
Testing correlation will be done by using linear regression. Standardized Coefficient Beta will measure correlation and a regression variable plot will visualize this correlation measure (Introduction to Regression).

The first factor is population density (see Map 1) which is calculated as the number of people in the county divided by the land area of the county using U.S. Census data (Quickfacts).

The second factor is daily vehicle miles traveled per capita (see Map 2). I obtained data from the 2010 California Public Road Data report (2010 California Public Road Data).

The third factor is PM2.5 (see Map 3). from the California Environmental Protection Agency Air Resources Board, which is a measure of fine particulate matter in the air that is 2.5 micrometers (around 1/10,000 of an inch) or less in diameter. Exposure to PM2.5 contributes to death and has the largest effect on children, the elderly, and people with heart or lung disease, asthma, or chronic illness. Engines are one of the contributors to PM2.5 in our atmosphere. This kind of particulate matter will be my measurement for air quality from each county (Air Quality: PM 2.5).

Fifteen of the fifty-eight counties had no data on 2010 PM2.5 State Annual Standard Designation Value measurements. This is the only factor with missing data. The State Annual Standard Designation Value for PM2.5 is defined as, "...the highest of three consecutive State Annual PM2.5 Averages, including the State Annual PM2.5 Averages for the listed year and the two years before then. The state annual PM2.5 standard is violated when the State Annual Standard Designation Value is greater than 12 micrograms per cubic meter" (Air Quality Trend Summaries).



Findings and Analysis

San Francisco was a clear outlier and was excluded from my data analysis. The first correlation test was between Population Density and Daily Vehicle Miles Traveled Per Capita (see *Chart 1*). After running a linear regression my Standardized Coefficient Beta turned out to be -0.330 . This medium correlation shows moderate support for the first part of my hypothesis. When a population increases in density, the amount of miles driven per capita decreases, just as my hypothesis predicted.

The second correlation test was between Daily Vehicle Miles Traveled Per Capita and PM2.5 State Annual Standard Designated Value (see *Chart 2*). After running a linear regression the Standard Coefficient Beta was -0.360 . This medium correlation shows moderate opposition to the second part of my hypothesis. Where the distances people drive is greater, the amount of pollution in the air is actually less.

This third correlation test is between Population Density and PM2.5 State Annual Standard Designated Value (see *Chart 3*). After running a linear regression the correlation coefficient was 0.154 . This value is low enough to mean that there is no direct correlation, positive or negative, between the two variables despite there being a moderate one in the first two analyses.

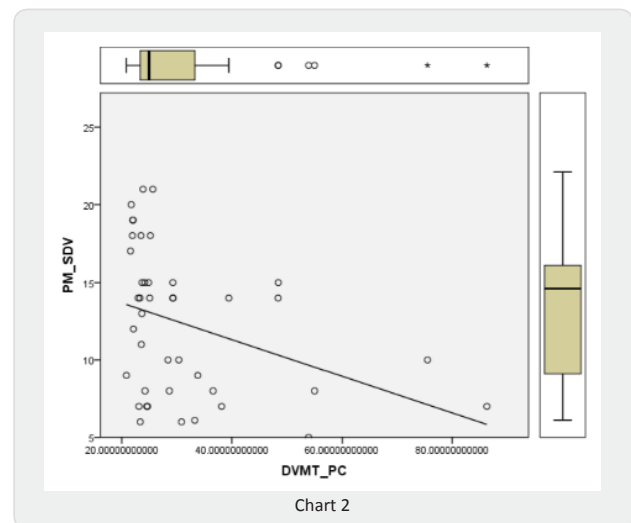
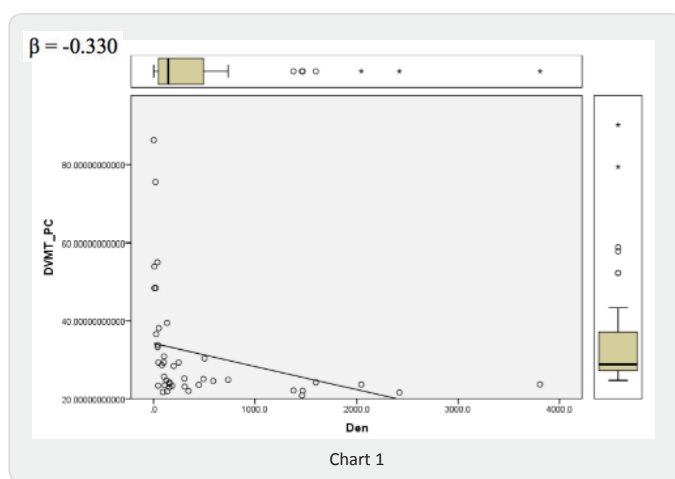
This research finds that areas with higher population densities have fewer miles driven per person. However it also finds that places with better air quality have longer average drives. The correlations are not strong, and may not agree, but they are close enough to assume that these measures are still factors in this equation. They just aren't

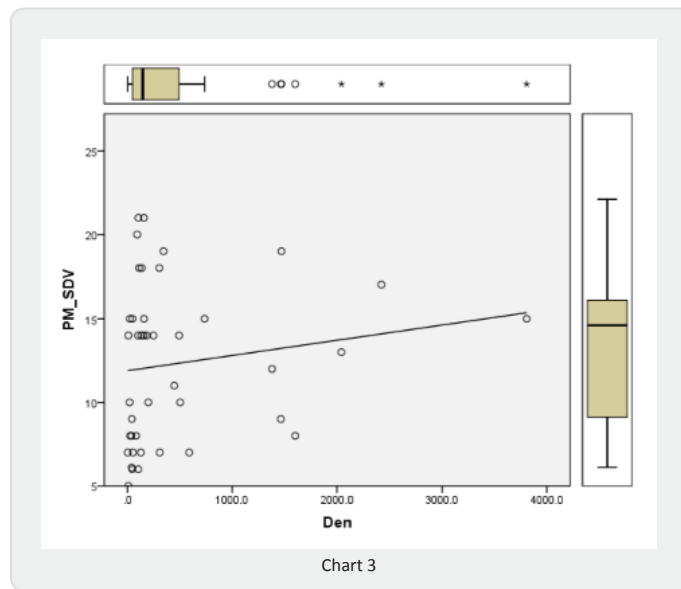
the only ones. That supports the viewpoint which led to my hypothesis. Any change is part of a system. This is why thinking through long-term decisions is so important. This research has traced back one of the deep rooted causes of air pollution by going a step further than making vehicles more efficient.

Conclusion

This analysis found some noticeable moderate trends with conflicting implications. While increasing vehicle efficiency is important, it is worth going a step further by examining it as part of a larger system which includes land use and population density. There is a medium correlation between population density and daily vehicle miles driven per capita, as well as a between vehicle miles driven per capita and air quality as measure in PM2.5 state annual standard designated values. These measures, while not the only factors, have enough correlation to be important in studying air quality and population density.

Alternative transportation infrastructure needs to have support when increasing density in order to handle the larger population. If this is not addressed with relation to population growth and density, the benefits of shorter distances will be outweighed by the pollution from congestion. Building properly dense areas should have the right incentives to facilitate healthy urban growth. Zoning and permitting development should incentivize ways to lower pollution and deter excess sprawl. Density alone does not enhance air quality. Accompanying land-use and infrastructure decisions, such as investment in alternate forms of transportation, should be concurrent with manageable future growth for better air quality.





	N	Minimum	Maximum	Mean	Std. Deviation
Den	57	1.600000000000	3807.70000000000	373.500000000000	705.239744950001
DVMT_PC	57	20.834384309240	163.086185044360	37.37431937380836	26.869692812897107
PM_SDV	42	5	21	12.34	4.691
Valid N (listwise)	42				

Descriptive Statistics

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Mathew Sterling

Urban Studies and Planning

Mathew Sterling graduated in June 2017, from Warren College with a Bachelor of Arts in Urban Studies and Planning. He is from San Diego. He will seek to work in the planning field in San Diego. He likes to walk and bicycle in good weather.

What advice would you give to your freshman self?

I would tell myself to not give up and to be open to all possibilities. I was struggling in my first major, but when I learned about the Urban Studies and Planning major, it was a perfect fit for me.

What excites you about the next year?

Next year, I hope to be in the middle of a planning related career where I can help the community.

What do you remember from Warren Writing?

I remember learning about Henrietta Lacks, what her cells contributed to science, and at what cost that ethics were violated. I also remember learning about how to analyze political issues which have more than one side.

How do you keep a “life in balance?”

Always having a skeptical but open mind. I want to listen to different opinions to better understand how other people think about an issue, but follow the evidence the best that I can.