The relation of urban development, neighborhood crime, and school performance

1. Problem statement and focus of analyses

While academic achievement constitutes a crucial factor for social justice as well as for socio economical status (e.g. Hoff, 2013; Sirin 2005), equal access to education is in the united States considered a fundamental right under the 14th amendment of the constitution (Plyler v. Doe, 1982). Poor academic outcomes on the other hand contribute to growing socio-economical injustice, poverty, and criminality, whereas ethnicity and socio-economical status (SES) are both predictors and effects of academic achievement, which suggests a reciprocal and mutually amplifying process between these and other related variables (e.g. Marchant & Finch, 2016; Miller, Votruba-Drzal, & Coley, 2019; Paschall, Gershoff, & Kuhfeld, 2018).

Public schools are usually hold accountable for student’s academic success (Domaleski, D'Brot, Keng, Keglovits, & Neal, 2018; Mittleman & Jennings, 2018; Sun, Kennedy, & Anderson, 2020). However, each school itself is embedded in a social and economical environment that exerts its very own influence on crucial factors for students’ learning success. Schools can provide learning opportunities and try to enforce student’s merely lawfully presence in the school building, but they have no or just very limited impact on environmental factors outside the school building; but these factors in turn constitute important student experiences that shape behavior outside and inside school as well as attitudes toward learning, and that also influence behavior at school. For example, while unemployment and crime rates of a neighborhood are correlated (Bender & Theodossiou, 2016), evidence from a longitudinal study in Chicago suggests that a neighborhood’s crime rate also exerts a lasting negative effect on school progress (Burdick-Will, 2016). Other studies from Chicago and New York corroborate the finding that neighborhood SES and crime rate impact student academic achievement (Laurito et al., 2019; Ruiz, McMahon, & Jason, 2018; Schwartz et al., 2016). This lack of academic success, on the other hand, constitutes a disadvantage for professional development and career opportunities that is likely to persist for students’ life times, hence hindering social-economical advancement, which in turn entrenches said social inequalities; as such disadvantaged and impoverished neighborhoods are most likely to be inhabited by racial minorities, this mechanism finally also perpetuates systemic racism. The current pandemic and the resurgence of the Black Lives Matter movement dramatically emphasize this inequality and its consequences, especially in times of limited resources and societal and economical tension and challenges.

Drawing on this background, I propose for my final capstone project the following scenario: the mayor of a metropolitan area in the US wonders if there is a way to use urban planning as a tool to develop local neighborhood communities in such a way that the development of local business and community services impact community safety, which exerts in turn a positive effect on academic performance.

More specifically, our mayor has already heard of studies suggesting that neighborhood crime rates have a negative impact on students’ academic performance, e.g. by enhancing the stress levels that students experience at home and/or on the way to school, which can also hamper student’s attention at school (e.g. Harding, 2009; Lord & Mahoney, 2007; Pelletier & Manna, 2017; Will, Stein & Grigg, 2019; Wodtke & Parbst, 2017). Some of his advisors have pointed out to him, that economical and recreational features of the urban environment also influence crime rates and perceived neighborhood crime. For example, researchers have found that an increase of parks tree canopy was inversely related to crime growth in Portland, Oregon, and Baltimore (Donovan & Prestemon, 2012; Troy, Grove, & O’Neil-Dunne, 2012) as well as - within a smaller-ranged experimental design - in Philadelphia (Garvin, Cannuscio, & Branas, 2013). At the same time, there is a positive relation between crime and the density of alcohol establishments (e.g. Groff, 2011; Toomey et al., 2012) or payday lenders and property crime (Lee, Gainey, & Triplett, 2014); the fact that the latter study’s did not find such a correlation with pawnshops suggests that this relation cannot be explained only by considering payday lenders an indicator of neighborhood poverty in general.

On the other hand, he also wonders to which degree neighborhood properties have an influence on crime and live quality. E.g., to which degree does the presence of gambling venues and bars or tabacco stores indicate - and maybe even influence - the presence of crime? Are there urban panning indicators for a healthy neighborhood community, e.g. the presence of parks, places to worship, the kind of restaurants etc.? E.g. coffee shops predicted in a study on gentrification in Chicago crime rates differentially depending on race and the kind of crime (homicide versus robbery; Papachristos et al., 2011), crime rates have been related to the presence of fast food restaurants (Askey et al., 2018), and in Baltimore, crime rates have been lowered by spatial regulation of alcohol-outlets and bars (Jennings et al., 2014). For that reason purpose, our imaginary major commissions a research institute to examine if properties of neighborhood communities that can be influenced by urban planning (e.g. permissions for certain businesses, support in form of financial support and advise for new startups, investment in infrastructure etc.) have an influence on the crime rate of the neighborhood, the way people perceive these venues, and if and to which degree finally urban structure, venue perception and crime rate exert an influence on academic performance.

Drawing on this, our mayor derives the following questions for researchers and/or data analysts:

1. Does neighborhood crime rates exert a considerable influence on students’ academic performance on public schools?
2. Can neighborhood features be identified that have an influence on crime and that in turn can be shaped and/or altered by urban planning?
3. Is it possible to influence academic performance positively by the use of urban planning to alter crime rates?
4. Can we derive from such features something like neighborhood indicators that might signal policy makers the urge of action?

2. Methods and data sources

In order to decide what computational methods and (or algorithms are most suitable to answer those questions, we have to transform them first into phrases that constitute questions that can be answered with scientific testing and hypotheses based research. However, in order to do that, it is also crucial to consider the available data, as different data leads to different approaches or can even limit in which way questions can be answered.

The questions above ask for academic performance, crime rates, urban features of neighborhoods, as well as reviews of these venues.

For the purpose of this capstone project, I assume the city of Philadelphia is the target of our analyses, as it is a ethnically and racially diverse American metropolis (City of Philadelphia 2020) with a significant poverty rate (Generocity, 2020). Hence, said data must relate to Philadelphia.

Philadelphia is located in the state of Pennsylvania. The Pennsylvania Department of Education assesses every student’s academic performance by administration of standardized cognitive curriculum based student testing (Pennsylvania System of School Assessment, or PSSA). PSSA results at the school level are the percentage of students that performed below a basic level, at a basic level, or at a proficient or advanced level. Reading math and science are assessed and reported separately. The Pennsylvania department of Education also reports the sum of proficient and advanced students. For ease of analyses, I will reduce the complexity of the data and combine for each school reading, science, and math results for all grades accumulated for proficient and advanced levels, which can be seen as indicators of academic growth. The Pennsylvania Department of Education provides also school performance measure at the building-level that combines several standardized academic performance measures, attendance and graduation rate, which I will also include in my analyses. The data can be retrieved from the websites of the Pennsylvania of Education with the exception of graduation rates and of the School District of Philadelphia.

As for crime rates, the City of Philadelphia and the Police Department of the City of Philadelphia provide crime incident data reports as *cvs*-files and as SQL API on their websites. Neighborhood venues, finally, including ratings and reviews can be collected, though limited in quantity, from Foursquare via a developer’s account.

Having assured that I have access to the data relevant for the planned analyses, I translate the questions from above in a final step into scientific questions that can be answered by the use of statistical tools. I derive the following questions:

1. Is neighborhood crime rate a predictor for student’s academic performance at public schools?

This is a regression problem with multiple predictors (total number of crime incidents sorted by crime category) and will be addressed accordingly. I will also use choropleth mapping as a visualization toll to show differences in neighborhood crime and academic performance for different school neighborhoods.

1. How distinct are these urban features of different school neighborhoods in relation to crime? In other words: Can patterns or types or clusters of such settings be identified that are predictive of crime rates?

We define neighborhood venues (e.g. category of local business, parks, playgrounds, and other recreational areas, hospitals, police stations etc.) as such urban features that can be shaped by political will and urban planning.

This is furthermost a classification problem and can be best solved in this context by the use of k-nearest neighbor algorithm. However, in order to test the mediation hypothesis (see next section), I will also perform a regression of the resulting clusters on crime rate.

1. The question if urban planning can bee used to influence academic performance through crime rates is what researchers call a mediation: does variable x (urban neighborhood features) influence variable y (academic performance) through variable z (neighborhood crime rate)?

Or: Are the effects of urban settings on academic performance mediated by neighborhood crime rates?

This constitutes a special regression problem; its solution is based on the results of the first two questions; I will have to test a mediation model with neighborhood categories based on the k-nearest neighbor analysis as a predictor for crime rate and academic performance. I will use a ANOVA based approach for this model test as suggested by Hayes and Preacher (2014).

1. Both quantitative ratings and written reviews of such neighborhood features have shown to be related to neighborhood crime. E.g. Shin (2019) investigated the relation between online reviews of neighborhoods around metro stations in Los Angeles and found a positive relation between neighborhood poverty levels and complaints about crime related safety, social environment and cleanliness. That being said, we derive the following scientifically rephrased questions:

4.1. Is there a positive relation between quantitative venue ratings and crime rate?

4.2. Is neighborhood crime rate reflected in the language used in venue reviews?

4.3. Is that relation dependent or independent of certain urban features or pattern of venues that might differentiate neighborhoods?

4.4. Do these reviews also predict academic performance? This, again, suggests a possible test of mediation.

The analyses as related to the quantitative predictor *rating* can be performed using regression based mediation models that include two mediators, one of which (neighborhoods) is most likely multi-categorial (based on the ideal number of k for resulting from the k-nearest neighbor analysis).

The analysis of the reviews is language based. The analysis of emotional content of a text is a common approach to this problem and usually done by the use of sentiment analyses, which is why I will use this method. Word clouds are best suited to visualize the results of these analyses. For regressions including sentiment analyses, one approach would be to employ logistic regression with crime rate or academic performance dichotomized (e.g. at the scale mid point or median).

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