Mapping urban diversity in New York City based on commuter data: Tracts with tall buildings display highest commuter diversity

AR2A011: Architectural History Thesis

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Abstract

Quantifying and mapping urban diversity is a newly emerging field of research. In this present thesis, I build on past and ongoing research. I expand diversity mapping to the mapping of commuter diversity. In particular, I map commuter diversity in New York City as a case study, and I demonstrate that areas with tall buildings are the most diverse. In addition, I suggest that commuter diversity correlates with urban diversity more broadly, which may be useful in the study of diversity where commuter data is most easily available. My thesis comes with a GitHub page that provides data and code and makes it easy for anyone interested to replicate the results.

Introduction

The availability of big data and computational resources have made it easier than ever to study cities in their everyday workings. A new emerging field of research is the quantifying and mapping of urban diversity (Baciu 2020, Baciu 2021a, Nazou 2022, Louvezijn 2022). At TU Delft, Baciu and his co-authors have published the first diversity maps and developed a six-step workflow towards mapping of urban diversity (Baciu & Birchall 2021, Baciu & Della Pietra 2021). In my thesis, I follow this approach with two new contributions. I study commuter data, specifically, and I do this in New York City.

Diversity, Big Data, New York City

Diversity across disciplines

The concept of diversity has been intensively used by many scholars and researchers to define impactful phenomena across different disciplines. In mathematical terms, diversity represents “the probability that different parties meet” (Baciu 2021b). This definition goes back to the 1940s (Baciu 2021b, Baciu & Birchall 2021). It was then first utilized in the field of ecology and linguistics (Fisher 1943, Yule 1944, Simpson 1949). Soon after, the concept was deployed in many other independent disciplines such as economics, physics, and virology (Baciu 2020). Quantifying diversity has proved to be useful to identify and address many global problems, including decaying biodiversity among others (Baciu & Birchall 2021).

Concept of diversity in Urbanism - lessons from Jane Jacobs

Diversity as a concept is also useful in urbanism, and it has been present in the field for a long time. Already in the 1960s famous journalist and theorist Jane Jacobs highlighted the importance of supporting diversity in cities (Jacobs 1961, Baciu & Birchall 2021). In her book “The Death and Life of Great American Cities’’ she described diversity as a concept that is inextricably linked with the urban centers. Jacobs called big metropoles “generators of diversity”. She believed diversity to be an intrinsic component of a vital city, something “natural”. According to her, diversity was a driving force behind the flourishing of the city and its economic growth.

A more contemporary take on diversity

Although many years have passed, the insights of Jane Jacobs are to some extent still relevant today. Nowadays, the notions of density and diversity are still predominant in the way cities are defined, for example in Europe (Dijsktra & Poelman 2012, Baciu & Birchall 2021). Although the cities we inhabit are being constantly rebuilt and go through numerous transformations, their diversity stays intact, or else the city decays. This phenomenon can be defined as a "golden rule of diversity" and traced back to ancient times (Baciu & Birchall 2021).

Cities are not only the place of great infrastructures, but most of all places of urban diversity (Baciu 2021b, Baciu & Birchall 2021). This proposition can be illustrated with many historical examples:

Although Babel was a city known for its tower, it was also a place known for its linguistic diversity. Another examples are Medieval fortifications. Medieval Cities had both fortifications and diversity of guilds. Meanwhile, the fortifications which were characteristics of Medieval Cities fell into oblivion while the "richness" of businesses stayed intact. Taking a more contemporary example, large traffic infrastructures of big cities are presently being transformed into promenades or bike paths, but the cities' cultural diversity prevails (Baciu & Birchall 2021).

All of the examples mentioned above illustrate that although the built environment constantly changes, the one thing that always stays unchanged is diversity. Therefore, one could conclude that "The city is its diversity" (Baciu & Birchall 2021).

First approaches to mapping urban diversity

Although it can be established that diversity is an immensely valuable concept in the study of cities, urban diversity has not been quantified with street-level resolution or mapped until recently. In their papers, Baciu and Della Pietra, and Baciu and Birchall create a blueprint for indexing and mapping urban diversity. By defining diversity as the "diversity of things that people do in the city" (Baciu & Birchall 2021) and amassing case studies from cities and entire countries (Delfshaven, Sassi, USA) they provide a framework that can be replicated and applied around the world. In my present paper, I add another case study, New York City, and I study commuter diversity in particular.

Understanding cities through big data

The previously mentioned papers showed that the data that is used to map urban diversity can come from many places: massive digital libraries, Google maps, or image collections such as SAHARA (Baciu & Birchall 2021, Baciu & Della Pietra 2021). In this present paper, I focus on census data, which represents yet another source that the data can come from.

Since various industries and universities have started to collect big data, more and more information about our cities becomes available to us. Open access databases on demographics, housing, economy, commuting, and many more types of information have become powerful tools for analyzing urban environments. Of course, the data must be processed to become useful. People who are interested in understanding cities, such as urban planners or architects, often do not have the necessary skills (i.e. coding) to perform such kind of analysis. As a consequence, there seems to be a lot of unused potential in the data that is available.

Therefore, this paper will use online available records and publish a very simple step-by-step workflow that allows anyone to analyze urban diversity using a Python script. The goal is to describe the process of the analysis in such a way that any person with minimum coding skills would be able to replicate the results. This way the barrier to accessing and processing this data is reduced, encouraging future researchers to capitalize on the vast amounts of available data to gain new insights into how our cities work.

Why New York City?

In my case study, I focus on New York City. Considering the history of New York as a "port of entry for southern and eastern European immigrants" (Foner 2013) and the cultural diversity which is visible to anyone in the city today, New York constitutes a relevant starting point for mapping urban diversity. Additionally, being one of the largest cities in the world, New York is very well documented and there is an abundance of open-source data which can be freely used. This is why New York City seemed like an appropriate choice for the next case study on mapping diversity.

Methodology

As mentioned before, the method used for indexing and mapping diversity in this paper is based on Baciu and Birchall, and Baciu and Della Petra's already existing framework employed to analyze Delfshaven and Sassi (Baciu & Birchall 2021, Baciu & Della Pietra 2021). Compared to these earlier papers, my present thesis makes use of different open-source city data to analyze diversity, but the framework remains mostly unchanged. The main steps stem from the previous papers and will be taken as follows (Baciu & Birchall 2021):

- Defining diversity.
- Describing the data collection process.
- Introduction of the classification system, granularity, and diversity index.
- Description of the mapping procedure.
- Validating the results.
- Description of possible application of the results in the field of architecture and urban design.

Chapter 1 - Defining diversity

The term "city" can be defined in many ways. What is a common denominator of all of those definitions is the mention of density and diversity. While it seems natural to think of a city as a collection of buildings that define it, we should not forget about its inhabitants. Without the people and their activities, there would be no cities. Among different types of activities, commuting is one that is geospatially relevant. One would expect then, that commuting plays an important role in the workings of a city.

Think about two spaces in a city. One of them is full of people who are in a constant, easy flow, while the other space does not allow for any free motion - all people are confined to their seats on immovable chairs. Now ask yourself which of these two spaces is the center of the city? Comparing the two spaces, it is immediately clear that only the first can be a city center.

The component of human motion in space should not be overlooked when defining urban diversity. In this thesis, I further develop on the already mentioned definition of diversity which is "the probability that different parties meet" (Baciu 2020). As Jane Jacobs mentioned in her book, the diversity in cities is so powerful, because it allows for the interaction of different people who can exchange ideas, knowledge, and opinions with each other (Jacobs 1961). Yet, to exchange ideas more efficiently, people often move in physical space. For this reason, it seemed appropriate to look at the diversity from the perspective of everyday commuting. Therefore the diversity in this paper will be measured as follows:

"Commuting diversity is the probability that commuters from different boroughs (for example of New York City) meet."

Following the argument made so far in my thesis, districts that attract commuters from many different boroughs should be regarded as urban centers, and one would expect that such centers further encourage urban growth and development. Working in a diverse environment enables people to exchange ideas, and it allows for more interaction between people of different backgrounds - contrary to the areas that lack commuter diversity.

A point that should not go unmentioned is the considering commuter diversity in New York City also considers ethnic and racial diversity, at least to some extent. Much research has shown that boroughs in New York City are still quite segregated. This means that high commuter diversity may also represent high ethnic or racial diversity. Therefore, it can be concluded that when looking at the diversity of commuters the result will indirectly contain some information on the ethnic and racial background of the workforce. Further discussion of the correlation between commuter diversity and ethnic and racial diversity should be relevant for upcoming research.

Chapter 2 - Collecting the Data

In this present chapter, I discuss data and data collection. As a data source, I use a database created by The New York City Planning Department for a “Metro Region Explorer” project (NYC Metro Region Explorer 2022). The record was created using several U.S. Census Bureau records from different departments (detailed information on data sources is available on their website in the tab “About”). Before going into detail on what kind of data was collected it is crucial to give some insights into what the US Census Bureau is.

2.1 History of US Census

It is important to acknowledge that the act of gathering information on citizens is hardly a novelty. The United States of America has a long tradition of collecting data. The US Census Bureau dates back to 1787 (Bohme 1989) when one of the articles in the adopted constitution required “numeration for the purposes of distributing tax revenue and apportioning political power” (Billingslea 2020). Later, in 1970 the first census information was recorded by the US marshals who conducted door-to-door data collection (Billingslea 2020). The process focused on counting “white males of 16 years and upwards” in each household in order to “assess the country’s industrial and military potential” (Bohme 1989).

Soon after the first data collection, the importance of collecting statistical records became apparent. With the push of Members of Congress, statisticians, and other scholars, new categories of information started to be collected, such as inquiries on manufacturing, agriculture, mining, government, religious bodies, business, housing, and transportation (Bohme 1989).

It is important to mention that the process of data collection at that time was completely different from what we use today. It was only in 1830 that “the marshals and their assistants began using uniform printed schedules; before that, they had to use whatever paper was available, rule it, write in the headings, and bind the sheets together” (Bohme 1989).

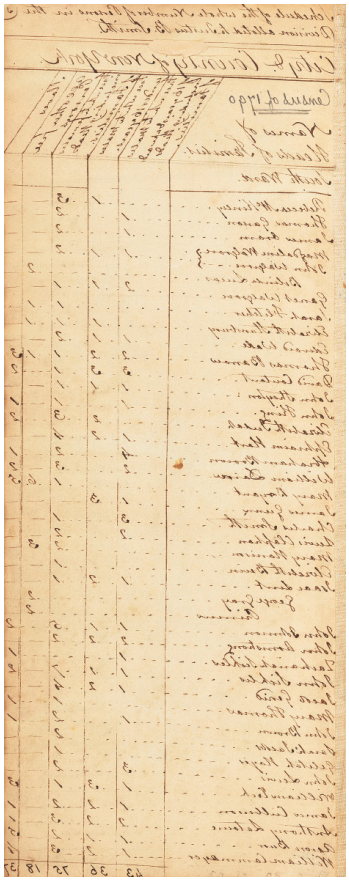

Figure 1. 1790 Census Form (Billingslea 2020)

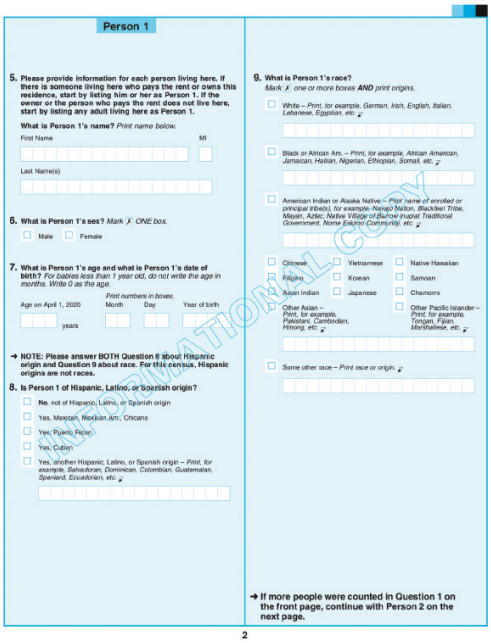

Figure 2. 2020 Census Form (Billingslea 2020)

With the rising interest in collecting data and the increasing number of topics and categories that the US census included, the process became very complicated. The first breakthrough came with the invention of the tabulation machine by Herman Hollerith in 1890 (who later became the founder of IBM corporation). With the use of this new technology, it became possible to automatize the data processing and, as a consequence significantly reduce the time needed for clerical work (Bohme 1989).
Another big step came with the commercialization of computers in the mid 20th century. By 1960 the data collection was carried out by mail and almost all the data processing was carried out by computers (Bohme 1989).
Since 1970 the census collection has been published in print as reports, often accompanied by maps. “In addition, the Bureau issued public-use microdata tapes, usually containing much more detail than the printed reports, for users with electronic computer facilities.” (Bohme 1989). Soon, with the new technological inventions, the data became available on diskettes, compact disks (Bohme 1989), and online.
Nowadays, the “census forms” can be filled out online and with the new data processing technologies researchers and data analysts are able to make sense of this ever-growing information. Through the collection of what was often mostly numerical data, we can now understand and analyze statistics and demographics but also social changes which occurred across many years.
An example of such changes is given by Anderson in her book “The American Census: A Social History” (Anderson 2015). Another example of understanding society through US census records is the exhibition “Who We Are: Visualizing NYC by the Numbers” in the museum of New York City (Billingslea 2020). The exhibition showcases how the society of New York can be understood through processing big data and visualizing it using computers.

Figure 3. “Landscapes of Inequality: New York City No. 2,” 2019. Herwig Scherabon. Courtesy Herwig Scherabon.
“New York City is a place of economic extremes, home to some of the wealthiest and poorest neighborhoods in the nation. Here, artist Herwig Scherabon visualizes these differences as abstracted forms. The height of the extruded cubes corresponds to median household income, with higher sections of the matrix representing higher incomes and lower areas representing lower incomes.” (Billingslea 2020)

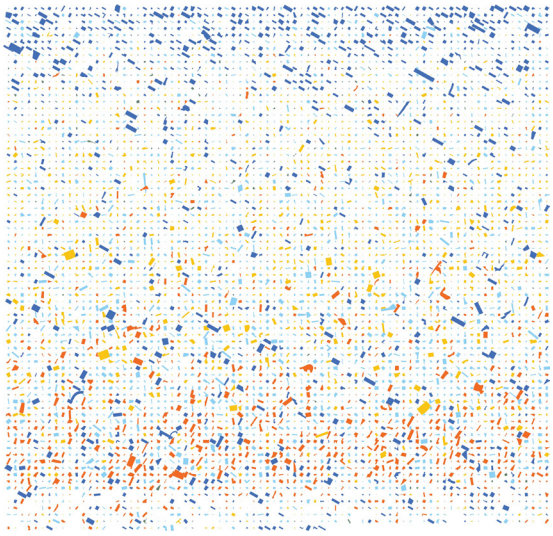

Figure 4. “Grid Series, 2019
Neil Freeman
Courtesy the artist

Here, census block groups are laid into a grid according to median household income. Freeman uses this reordering to show the distributional differences across tracts. The groups are color-coded by borough, with the colors derived from the borough flags. The size of each group corresponds to the total population of the area.” (Billingslea 2020)

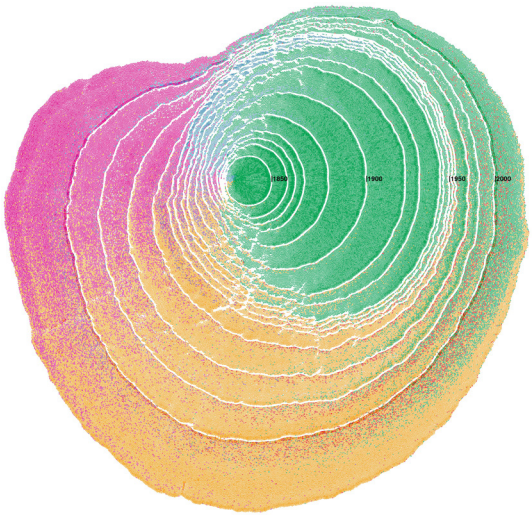

Figure 5. “Simulated Dendrochronology of U.S. Immigration, 1840-2017, 2019
Pedro Cruz, John Wihbey, Felipe Shibuya
Courtesy Pedro Cruz, John Wihbey, and Felipe Shibuya

The growth of cities is shaped by a host of external factors, as they register information from the environment and encode it in their structures. New York City has been molded by decades of immigrant arrivals, their movements determined by global political and economic conditions. Here, an interdisciplinary team of faculty from Northeastern University has visualized the shifting origins of immigrants as growing tree rings.” (Billingslea 2020)

In my present thesis I aim at illustrating that the collected data can also be used in the field of architecture and urban design. By creating maps based on the data processed by computers, I show that we can get new, unprecedented insights into how our cities work. My approach would not have been possible without the adoption of modern technologies and the collection of big data.

2.2 Description of extracted data

The database that I use for analysis can be directly downloaded from the NYC Metro Region project website (NYC Metro Region Explorer 2022). The record contains information as illustrated below and describes the situation from the 2010 US Census record. For every NYC tract, the number of workers from each borough is defined. Each data entry also contains geographical coordinates of the tracts which I used to visualize the results on a map.
A more detailed description is available through the GitHub page of my thesis: https://github.com/raszkap/New_York_Mapping_Diversity

- geoid - an official unique code of each tract
- cw_bx - number if commuters who work in that particular tract and live in bronx
- cw_bk - number if commuters who work in that particular tract and live in brooklyn
- cw_mn - number if commuters who work in that particular tract and live in manhattan
- cw_qn - number if commuters who work in that particular tract and live in queens
- cw_si - number if commuters who work in that particular tract and live in staten island
- geometry - this is the column which contains the data on shape and geolocation of the tract

Figure 6. Description of the used data

Chapter 3 - Performing the analysis

Once the data are collected, they must be analyzed. In order to do so, one must choose some analytical framework. Following the framework I have chosen (Baciu & Birchall 2021) three main choices are necessary for diversity analysis:
- A system of classification has to be employed.
- The granularity of the performed analysis must be defined.
- A diversity index to quantify urban diversity has to be chosen.

All these three steps will now be described in more detail.

3.1. Classification system

The records used for the analysis come with an already pre-established classification system which is based on the new york boroughs from which the commuters originate. Consequently, there are 5 different classes in the dataset - Bronx resident, Brooklyn resident, Manhattan resident, Queens resident, and Staten Island resident.

3.2 Granularity

Having chosen the classification system, the next step is to define the granularity of the analysis, which describes “the amount of detail considered in our evaluation” (Baciu & Della Pietra 2021). In the case of the data, we employ the scale of our analysis which is one commuter. In other words, for every commuter who is included in our database, their place of residence is defined.

3.3 Diversity index

Finally, an analytical way to quantify diversity must be chosen. It has already been established how many commuters from different parts of New York City work in certain areas, but it does not explicitly indicate where we can observe more diversity among employees. Following the methods of the previous papers (Baciu & Birchall 2021, Baciu & Della Pietra 2021), I can calculate diversity using Simpson’s diversity index. The use of this method will reduce scale dependency and provide us with a quantitative score of diversity which can be later visualized on a map. The geographical resolution on which Simpson’s index is computed is the New York City “tract”, which represents a small neighborhood.

$$D_s = 1 - \sum \left(\frac{n}{N}\right)^2$$

D_s = Diversity Index
n = Number of individuals for each species
N = Total number of all individuals

Figure 7. Simpson’s Diversity Index
Pappas, J. (2020)

Chapter 4 - Synthesize the results

4.1 Process of mapping

Having created a table of numbers that defines diversity for each tract of New York City, we have to consider what would be the most suitable way to visualize the results. Since the paper is created with architects and urban planners in mind, it seems like an obvious choice to present the result using a map as it is the main tool of urban analysis in those fields (Baciu & Birchall 2021).
The map (Figure 8) is created using a python script and a geopandas library which is often used to work with data containing geographical coordinates (to replicate the analysis and mapping see the GitHub page: https://github.com/raszkap/New_York_Mapping_Diversity).
The colors on the map represent the score of a diversity index. Dark blue represents high diversity (with the darkest blue representing Simpson’s index = 1), while light blue indicates low diversity (with white representing Simpson’s index = 0).

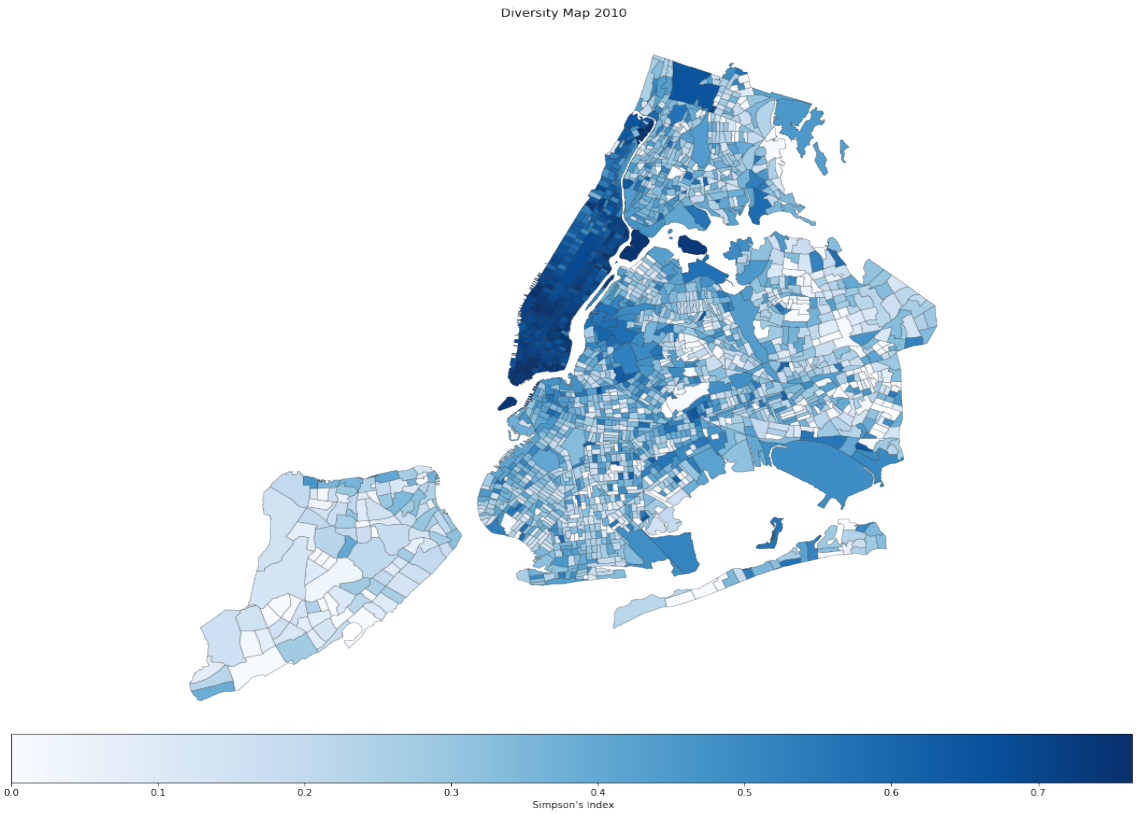

Figure 8. The generated diversity map

4.2. Preliminary observations

Let's see what the main trends in the generated map are. Looking at the commuter diversity map, it is clear that the Manhattan borough has, in general, the highest score of diversity. This is of course a result that one could have predicted as Manhattan is considered the center of New York City. Within Manhattan, there are sever clusters that distinguish themselves as more diverse. These represent urban centers around Times Square, Financial District, and Columbia University.

However, some of the results are rather surprising. Three islands turned out to be very diverse (Figure 9):

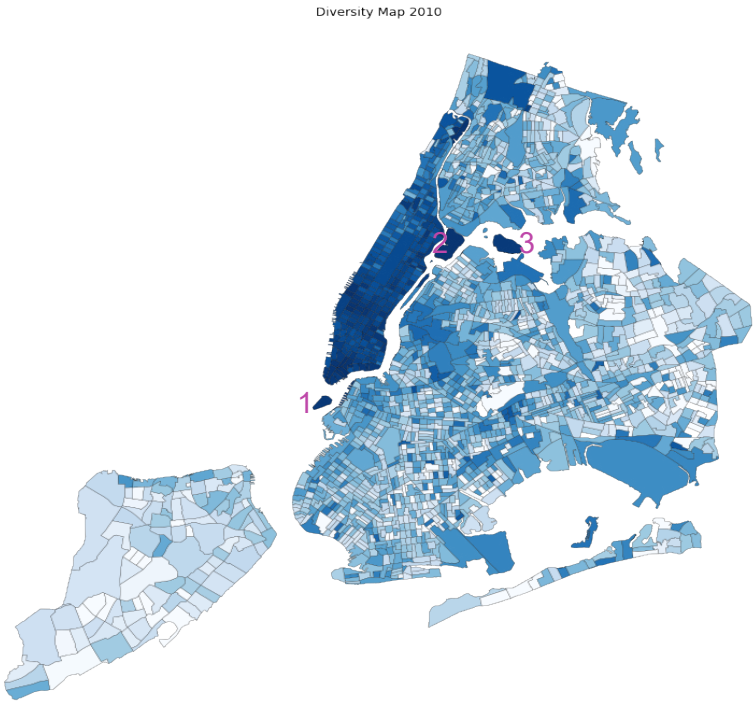

Figure 9. The generated diversity map

1 - Governors Island which contains mostly green public spaces such as Lavender Fields, playgrounds, and picnic spots
2 - Randall's and Wards Islands which are the places of two big parks and other public facilities
3 - Rikers Island which houses a prison

What one can see is that commuters in this region come from many different areas. These areas house very important urban facilities, which qualifies them as centers. It could have been that most of the commuters at the islands come from the closest, adjacent areas, but it seems not to be the case. In contrast, the people come from many different places because the facilities are relevant to the city, and people with different skills are required to run them.
I would like to attract some attention to a limitation of the present map. As can easily be recognized, there are a few lines along which diversity seems to score higher. Having a closer look at those lines, one can deduce that they overlap with the boundaries of the 5 New York boroughs which are used to classify commuters into different commuter groups (Figure 10).

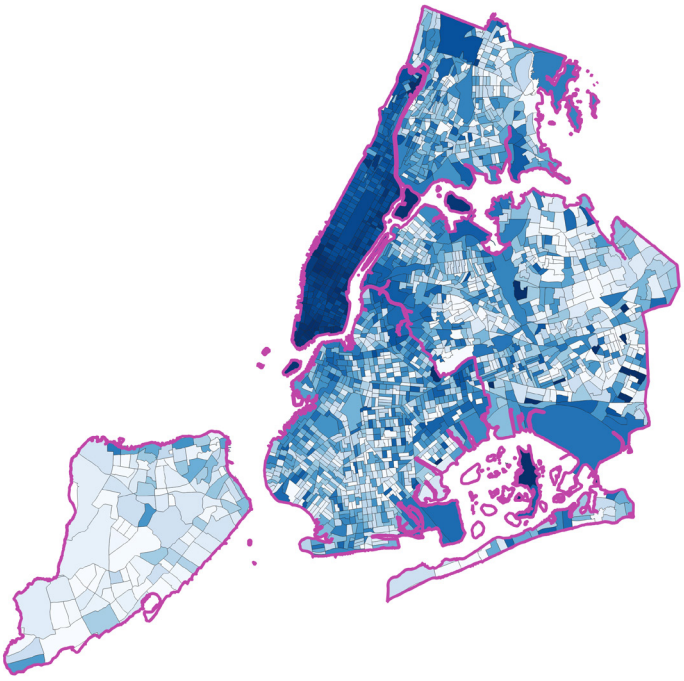

Figure 10. The generated diversity map overlayed with the boroughs boundaries

The reason behind the high diversity along borough boundaries is probably that people who live in the zones along the borough boundaries may increase the diversity even if they work very close-by in the adjacent borough. Such commuting raises the diversity score only along the boundaries between boroughs. Imagine a person who lives in Queens, just one block away from Brooklyn. If this person works in Brooklyn, it may take them as little as 5 minutes to commute to work. In most cases, such close commuting is predominant, and more of it does not raise the diversity score. However, along boundaries, it does. This is why we see a higher commuter diversity along the New York boroughs boundary lines. Thus, the limitation of the map is here a consequence of the classification system that was chosen. Changes in the classification system could avoid this unwanted effect. Interestingly, we see that along the borough boundaries diversity fades away on locations further away from Manhattan. Diversity is higher in the areas closer to Manhattan and it decreases with distance.

Chapter 5 – Validation

By following an analytical framework I have *theoretically* achieved a valuable diversity map. However, I must also validate the result using an unrelated method to check if the results of the map go in hand with what actually happens. To do so I will evaluate historical and present-day photographs of 3 areas that turned out to be most diverse.

The 3 spots were chosen, shown in Figure 11.

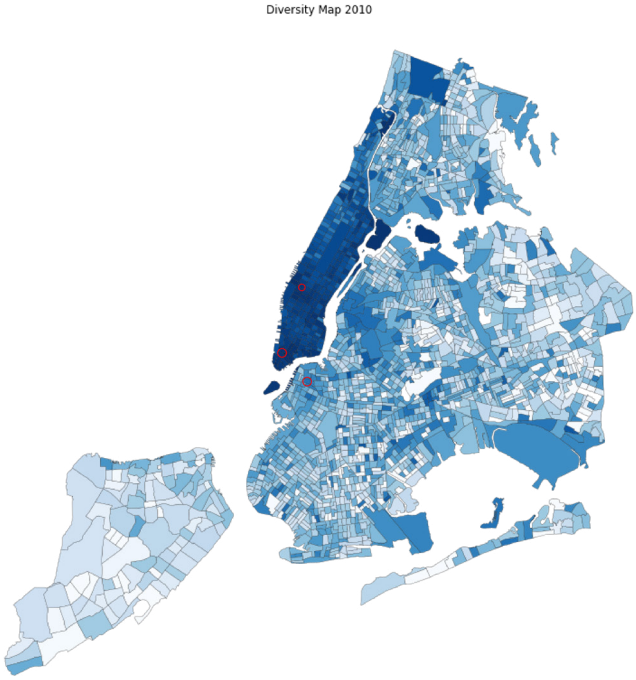

Figure 11. Several places which are distinguished by a higher diversity score

5.1 Wall Street

Wall Street, also known as Financial District, has been an important urban center ever since New York City was founded. It is here where the first settlements were erected in the 17th century (Nevius 2018), initially as New Amsterdam. Since then the district has undergone many transformations but it has consistently stayed an important spot within urban space. The evaluation of historical and present-day photographs shows that tall buildings in particular have attracted people from any distance, not just from the immediate neighborhood.

Figure 12. “171 Washington Street; View down Cortlandt Street, showing the L.E. Waterman Fountain Pen Company and Waltham watches, New York City, undated (ca. 1890-1900)”. (Urban Archive 2022)

Figure 13. 171 Washington Street (Google, 2022)

5.2 Times Square and Hell’s Kitchen

Times Square is seen by many people as the center of Manhatten, and for Hell’s Kitchen, just North of Times Square, the name seems to literally indicate high diversity. Although the district of Hell’s Kitchen is thought of as a center of crime and violence in New York City, one must admit that it still plays an important role as urban “center”. Similar to Wall Street, the district has undergone several transformations triggered by events such as the opening up of a port authority in the neighborhood or the plan to revitalize the area by the city council in the 1960s (Schneider 2020). Although the urban fabric of the area has changed, it is to this day one of the busiest neighborhoods in New York City, which can be supported with historical and present-day photographs.

Figure 14. “Apollo Theater 42nd Street;
North side of 42nd Street between 7th and 8th Avenues with installation by artist Jenny Holzer ‘Truisms’ on theater marquee.”. (Urban Archive 2022)

Figure 15. Apollo Theater 42nd Street (Google 2022)

5.3 Downtown Brooklyn

Downtown Brooklyn is an example of a vibrant center that has sustained high diversity since its very beginnings, outside of Manhattan. Before becoming an NYC borough it was a place of one of the first Dutch settlements in the region. Soon it became a center of the manufacturing industry and now it is often described as “a teeming sub-metropolis” (Fons 2005). This is why it was no surprise that the spot became visible in my analysis as a very diverse area. Photographs, especially from the present day, support that this is a place of high urban activity and diversity. Photographs, especially from the present day, support that this is a place of high urban activity and diversity.

Figure 16. “Willoughby Street and Jay Street;
[Willoughby Street at Jay Street, BMT Broadway Line, Brooklyn, NY]” 1915 (Urban Archive 2022)

Figure 17. Willoughby Street and Jay Street (Google 2022)

5.4 Diversity promotes transformation

What all of these places have in common is how diverse they are, and how much they have changed, although diversity has stayed. Comparing the historical and present-day pictures we can barely recognize that the images represent the same spots in the city. This supports the point that I brought up before in the paper, namely that, while the infrastructure and buildings in our cities change, diversity stays. Both historical and present-day photos prove that the areas have always been rather busy, with a lot of people driving or walking by, and there were many different types of businesses or activities: there was high density and diversity. However, almost none of the infrastructures stayed unchanged.

Secondly, the common dominator of all of the photos is the predominance of rather tall buildings in comparison to the adjacent areas. This brings up a hypothesis that tall buildings are in fact diverse buildings.

Chapter 6 - Proposed application

The validation based on the historical photos has proven that the outcomes of the analysis are in line with the actual situation in New York City. High commuter diversity as computed in this thesis does represent actual high commuter diversity as well as high urban diversity more broadly. The last question is: how can the map that I created become useful in architectural or urban practice?

The answer to the posed question becomes clear after one tries to compare the generated map with other maps of the region. As an example, let’s compare a map of building heights with the diversity map generated for this paper (Figure 18).

It is rather clear that the diversity corresponds to the height of the buildings. The higher the buildings – the more diversity is visible. One can dare to say that the tall buildings are in fact diverse buildings. This should be a hallmark insight, and it comes supported by empirical data. Knowing that tall buildings are diverse buildings can help architects design such buildings. Presently, many tall buildings are rather monotonous in their architectural design. They are boxes with countless identical windows. Knowing that tall buildings are diverse buildings could free the architect to make this visible on the facades. Herzog & de Meuron’s Leonhard Street skyscraper could be one example that goes in this direction

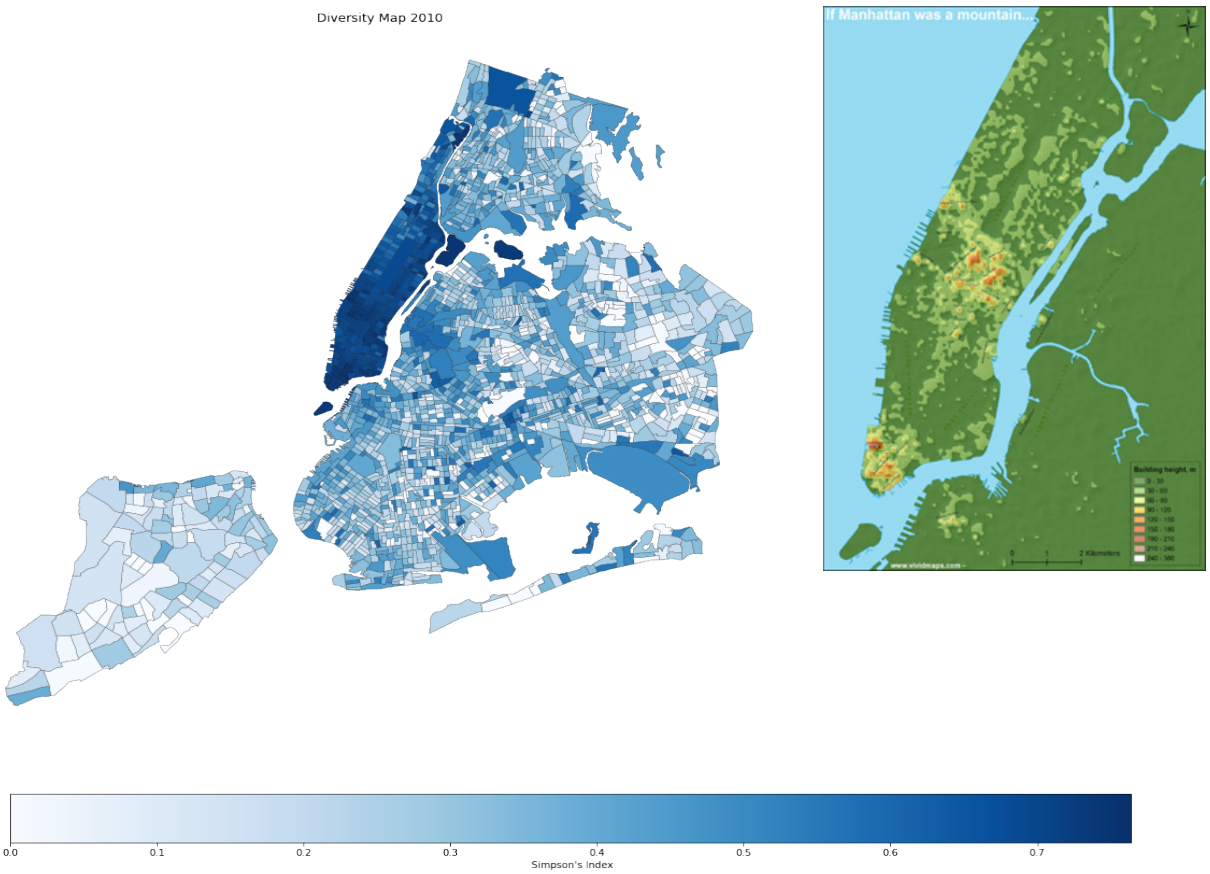

Figure 18. Comparison of the diversity map and a building heights map (Coneybeare 2018)

The Rockefeller Center may serve as an example, to illustrate that the activities that take place in tall buildings have long been quite diverse. Nowadays the complex is used as a “network of business, television studios, shopping” (Parrella 2018), but it is also full of shops, restaurants, and many more. In addition, it houses popular tourist attractions (such as the famous “top of the rock” observatory. It is also a popular and valued public space. Everyone has heard about the famous ice-skating ring and the Christmas tree put up in front of the plaza of the building every year.

Figure 19. Rockefeller Center (Parrella, C. (2018, November 28))

Figure 20. Rockefeller Center Skatig Ring (Cross 2020)

Historically the complex was used among others as “the personal office space of the Rockefeller family”, music hall, (Parrella 2018), restaurant, and even food production hubs during the WWII (Hzdg 2022).

Figure 21. Historical photo of the observatory at the Rockefeller Center (Hzdg 2022)

Figure 22. Historical photo of the “Radio City Music Hall” (Hzdg 2022)

Figure 23. Historical photo of the “Rainbow Room“ restaurant (Hzdg 2022)

Figure 24. Historical photo of the skating ring (Hzdg 2022)

Figure 25. Historical photo of the food production at the Rockefeller Center during WWII (Hzdg 2022)

Regardless of time passing, the complex of the skyscraper has stayed extremely diverse, attracting people from all over New York City.
Now that we know that tall buildings more generally attract diversity, urban planners could use this knowledge. For example, they could use tall buildings to attract urban diversity where it is most needed.

Conclusion

My present thesis has demonstrated how to use a dataset of commuter data, how to generate a diversity map from the data, and how to use such a map in meaningful ways. In addition, my thesis has indicated that commuter diversity and urban diversity may often be correlated, and that tall buildings are often diverse buildings. I have come to this latter conclusion by comparing the heights of the buildings in New York City with my diversity map. Continuing in this research direction, architects and urban planners could go on to compare the map that I created with other information, unfolding consequent insights into the urban dynamics of New York City. The possibilities are endless. By publishing my thesis and providing an associated GitHub page with detailed information and data for replication, I hope to inspire people from the field to try to get a deeper understanding of what big data has to say about our cities. Next to my thesis, two other theses in the same research group are presently written about urban diversity (Nazou 2022, Loevezijn 2022). Quantifying and mapping urban diversity, including commuter diversity, is a new research direction pioneered in this group, but I hope that other researchers should join forces with us.

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