euro geo

Research Article

Quantifying displacement: Using turnover data to measure physical and psychological neighborhood change

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Abstract: Population displacement is difficult to measure, but quantifying its presence is critical to delineating the scope, scale and potential causes of displacement's effect in urban areas. This paper considers whether the widely available data used to measure turnover can be effectively used to measure other forms of population change. The article presents two new metrics, the Fresh Faces Ratio and the Replacement Index, that better capture some of the nuances of physical and psycholog-ical displacement. It then applies these metrics to city quarters within the city of Zurich, Switzerland, correlates them with turnover and new construction statistics, and assesses their accuracy against residents' perceptions of change. The research finds that both metrics offer suitable proxies to identify areas where exceptional population changes are taking place, and where residents have a strong sense of these changes. The new metrics can help assess what physical or psycho-logical displacement may or may not result from urban development and new housing construction. Since the new metrics use turnover data already widely available, they are easily adaptable to less data-rich contexts than Zurich.

Highlights:

- Refashioning turnover data for new metrics measuring displacement
- Evaluating new metrics against resident perceptions of change
- Potential applicability for comparison across varied data contexts

1. Introduction

Urban areas absorb and churn new waves of incomers from far and near, endlessly remaking neighborhoods, cultures, and communities. Local, regional, and international migrations all influence the trajectories of an urban area over time, driven by multiple factors including an elite with ever more mobility and disparate ties across global communities (Sklair, 2005); local and international climate migrations (Boas et al., 2019), and personal residential choices (Rérat, 2020).

Urban transformations are also driven by developments responding to financial, environmental, and demographic pressures and incentives. In Zurich, Switzerland, densification has been a legally binding federal target since the approval of the Federal Spatial Planning Act (SPA) in 2013, intended to optimize fossil fuel use and reduce urban sprawl. Zurich needs new housing due to an anticipated increase in net migration, an extremely low vacancy rate, and a high percentage of renters. The SPA, coupled with housing market pressures, has led the city planning office of Zurich to undertake aggressive campaigns to build new housing over the last twenty years.

A key concern with new development is its potential to further exacerbate the inequalities rampant in contemporary urban life. New construction within urban neighborhoods is frequently perceived to bring a slew of negative changes, including increasing population instability and displacement. This article focusses on displacement as one of the most fundamental spatial inequalities associated in the popular imagination with new development (Chapple, 2019; Millard-Ball, 2020; Teresa, 2022). Central to urban inequalities, displacement is notoriously complex to measure (Chapple, 2019, p. 317; Easton et al., 2020). Turnover, on the other hand, has long been a standard way to measure population fluctuations, capturing the total of incoming and outgoing moves as a fraction of the total population. The metric is used in variations around the globe.

Combining incoming and outgoing moves in the calculation of turnover smooths over some key distinctions in the type of population fluctuation taking place, potentially eliding distinct processes that feel very different to residents on the ground. This article posits that with the same data used to measure turnover, several new metrics can be created that better capture elements of population displacement as urban areas change. While displacement is complex and multi-faceted, a basic and widely accessible proxy measure that identifies its likelihood would help in addressing its ongoing presence in urban communities.

Zurich is an extremely data-rich environment, and offers an excellent opportunity to explore new methods for measuring displacement proxies and their relationship to new urban housing developments. This research tests two new population change metrics, created from the same base data as turnover. It then assesses how the new metrics correlate to turnover, and corroborates their ability to detect aspects of displacement by checking them against qualitative perceptions of change in the local population, in the context of Zurich's ongoing densification.

As Zurich consciously remakes and transforms itself, it offers an opportunity to understand how these transformations affect residents living within the city. Densification and increased capacity to accept newcomers are laudable goals in a world desperately in need of limiting fossil fuel use and struggling to welcome migrants from near and far. As the city transforms, what happens to existing residents? How do they perceive

changes to the neighborhood? How do we measure and assess this urban dynamism in a way that captures the changes urban residents are experiencing?

This paper posits that turnover, one of the oldest and most ubiquitous metrics for measuring population flux, can be refashioned into new metrics that capture important and under-measured contemporary urban dynamics such as physical and perceived displacement. By developing two new related metrics, comparing them to turnover, and assessing resident's perceptions of change across the city and in outlier cases, I find that while turnover mostly operates very similarly to the new metrics, when they are used in combination the new metrics capture urban dynamics better aligned with residents' perceptions of change. Because turnover data are widely available, the new metrics could be used to identify areas undergoing exceptional change, even where more resource intensive data are not available.

2. Research framework

Residential flux is endemic to cities, and the relationship between this flux and urban development, while much debated, requires further study, through quantitative and qualitative methods. Urban development and urban inequality are deeply intertwined, both in academic scholarship and in popular perception. The inequality embedded in development manifests in multiple ways; this paper focuses specifically on inequality in the form of potential displacement of existing residents. Turnover captures broad population flux, but fails to capture nuances of this displacement, either physical or perceived. This framing lays out the broad context of displacement's role in urban inequalities and development. It outlines the history of turnover's dominance as a population metric, in order to leverage turnover's ubiquity to propose two metrics that better capture fluctuation-driven inequalities.

2.1 Urban development and inequality

The rise of professional relocation following globalization's restructuring of cities as critical economic nodes in global networks is well documented (Camillo Boano & Francisco Vergara-Perucich, 2017; Friedmann, 1986; Sassen, 2001). The creation of a mobile global elite occupying cities around the world followed (Sklair, 2005), as well as the subsequent restructuring of social classes and economies within cities (Fainstein, 2001; Sassen, 2012). While global cities have become targets for relocation, they don't serve all of their existing inhabitants well (Amin, 2013). Global economic networks have created segregated economies of served and servant classes, at times violently (Sassen, 2014), as well as spatially segregated parallel cities within cities (Fainstein et al., 1992; Málovics et al., 2019; Marcińczak, 2012; Méreiné-Berki et al., 2021). City regional developments can and often do exacerbate and sustain income inequalities, in part due to the policies designed not to serve social needs but instead to compete economically with other regions (Brenner & Wachsmuth, 2012; Fainstein, 2001).

The income inequality of celebrated global cities relates in part to their high cost of living, and lack of affordable housing (Cramer-Greenbaum, 2020; Fainstein, 2001). These cities have also become targets for wealth relocation, as asset-backed capital becomes ever more valued, and cities competing for investment increasingly compete to attract worldwide capital (Amin, 2006). Cities eager to develop court global capital influx, and investors both catalyze and profit from the increasing value of housing and subsequent financialization of real estate markets. These processes are well underway in Zurich, with a well-documented increase in the use of housing as an investment asset and financial tool (Theurillat et al., 2015). One area of Zurich undergoing some of the most intense development in the last twenty years is Escher-Wyss, which has been the frequent focus of studies on gentrification and population shifts in Zurich (Fang & Kunzmann, 2008; Kretz et al., 2014; Rérat, 2018, 2019).

The cycle of capital influx and urban development can lead to inequality in many ways (Mishra et al., 2022). Development of urban areas, often in the form of large developer driven construction projects, creates advantage and wealth for some, and displacement and disadvantages for others (Amin, 2006; Fainstein et al., 1992; Tonkiss, 2013; Zukin, 2008). The potential for displacement in urban development is large, and one of the most prevalent manifestations of the urban inequality catalyzed by the restructuring of cities into global financial nodes.

2.2 Displacement

As development takes place, how can we measure whether displacement is also occurring? As a broad-brush metric, turnover can't capture the nuances of the change people fear as they see the city developing around them. Displacement has both a physical and a psychological aspect, with both aspects carrying heavy burdens for populations experiencing them. Displacement is frequently cited as a grave fear for existing residents watching their city transform (Chapple, 2019; Millard-Ball, 2020; Teresa, 2022). The fear takes on many guises – nimbyism, anti-gentrification activism, political campaigning, to name a few (Lees et al., 2010, pp. 317–318, 2015; Teresa, 2022), most of which are underlined by a fear of displacement; either existing residents will be forced to leave, or will stay but no longer feel they belong.

2.2.1 Physical displacement

Physical displacement is notoriously difficult to measure (Chapple, 2019, p. 317; Easton et al., 2020), although recent scholarship has made significant inroads using locally specific eviction records, census data, and consumer registrations to begin to assess the scale of physical residential displacement taking place in urban areas (Atkinson, 2000; Freeman et al., 2016; Freeman & Braconi, 2004; Ramiller, 2021). One fundamental challenge is distinguishing displacement from voluntary moves; at what point on the spectrum of residential mobility decisions does a move become forced? Subtle distinctions govern this conversation, and causes of physical displacement can be manifold (Easton et al., 2020). Evictions, rental increases, barred access to new facilities, discriminatory lending practices, and many landlord practices to encourage vacation fall somewhere on the spectrum of forced or involuntary moves. Unseen pressures on residents, as well as biases in collecting data all contribute to the murkiness of measuring the scale of physical displacement (Ramiller, 2021).

2.2.2 Psychological displacement

In addition to physical displacement, displacement has been studied and theorized as a perceived phenomenon, describing residents feeling that the ground has shifted under their feet. They remain, but the neighborhood where they remain is one they no longer recognize, and one where they feel they no longer belong (Davidson, 2009), or that they have been culturally displaced (Tuttle, 2022). Perceived displacement can be just as violent and disruptive as eviction or forced moves (Elliott-Cooper et al., 2020), and create lasting memories of violence through generations (Creţan & Doiciar, 2022). Perceived displacement contributes as much if not more than physically displacement to the uneven distribution of

benefits and disadvantages stemming from urban developments. Psychological displacement is equally difficult to measure without in-depth social surveying of local populations, which is rarely conducted extensively or longitudinally, or with meaningful comparative methods.

2.3 Urban dynamics and population flux

Conversations assessing the positive and negative aspects of population flux and urban turnover are frequently distinct from conversations focused on urban inequality and displacement. But population fluctuation is how populations change, and as cities have developed, these populations changes often advantage some to the disadvantage of others.

Flux is a defining characteristic of urban life (Maccioni & Zebenigus, 2016; van Diepen & Musterd, 2009), and cities have long acted as gateways for people to create new lives (Price, 2008). While instability is often categorized as negative, the literature on turnover finds aspects of both positive and negative change.

Turnover was introduced into the literature as a measurement of population instability to which increased social disorganization and delinquency were attributed (Shaw & McKay, 1942). While this original study is outdated and problematic in many of its assumptions about race, delinquency, and heterogeneity in communities, the idea that too much population change contributes to societal challenges is persistent in the literature. A vast number of studies document a correlation between high population fluctuation and negative social statistics, without demonstrating, although sometimes assuming, a causal relationship. High turnover continues to be tied to many social ills, including decreased community cohesion and weaker social ties (Alesina et al., 2016; Alesina & Ferrara, 2005; Bruner, 2015; Pemberton & Phillimore, 2018; You, 2012), weakened support structures for elderly residents (Burholt & Sardani, 2018), weakened support for urban poor, leading to racialized encounters (Creţan et al., 2022), and increased rates of crime (Rotolo & Tittle, 2006; Shaw & McKay, 1942).

High turnover has also been documented as a result of landlords evicting current tenants in anticipation of rising house prices, a precursor displacement to impending gentrification (Freeman et al., 2016; Slater, 2009). Although high turnover has been theorized to be a result of gentrification (Lees et al., 2010), gentrifying neighborhoods have sometimes been found to be more stable than socio-economically similar non-gentrifying neighborhoods in some cases (Freeman & Braconi, 2004).

Other studies focus on more positive consequences of population change, showing how population flux introduces new concepts, ideas, and innovation to populations, and disseminates these innovations to other locations (Brown & Tousey, 2020). A dynamic population allows exposure to new influences, can propel economic growth, and can enhance social trust (Alesina et al., 2016; Bruner, 2015; Erickson et al., 2018; Kanakis et al., 2019; Marcus, 2008; You, 2012). Conversely, a lack of new residents can cause problems for cities, such as unbalanced age distributions, and a lack of working age residents (Borsellino et al., 2021).

The divergent literature on turnover reflects the embodied duality of change – through change cities learn, grow, and evolve, but the process can simultaneously be uncomfortable, disorienting, disruptive, and even violent, and changes often benefit some at the expense of others. Our current metrics for measuring population change don't capture this duality, but capturing these nuances might help gain from population change's benefits while minimizing its negative effects.

2.4 Turnover metrics

Neither the physical nor the psychological aspects of displacement are captured by measuring turnover, which combines inflows and outflows of residents as a percentage of the population. Additionally, the method for measuring matters; qualitative studies of displacement document large-scale injustices and a growing problem, while quantitative studies tend to categorize displacement as an occasional side effect without widespread impact (Brown-Saracino, 2017). In testing or devising any new quantitative metric for measuring population change, it is valuable to cross check the measurement with perceptions of change, to bridge the above-cited gap between the qualitative and quantitative research on the subject.

Turnover is a long-standing metric of population stability (Bailey & Livingston, 2007; Dennett & Stillwell, 2008; Robertson, 1982), and is often used as a proxy measurement for other types of social and economic population shifts (Brown & Tousey, 2020). There is much discussion of the nuances of how turnover is measured, such as whether births and deaths should be counted or not, whether internal migration should count separately from external migrations, and what is the minimum distance or area size that constitutes a move (Brown & Tousey, 2020; Dennett & Stillwell, 2008). Related metrics of population entropy focus more on biological factors such as reproduction and life expectancy, excluding local or external migrations (Demetrius, 1989). There have been many advances in modernizing how population data is collected (Lazar & Chendrayudu, 2019), and in leveraging data collection from social media better understand population vibrancy (Lang et al., 2022; Ouyang et al., 2022), and daily spatial densities (Zhang et al., 2020). There has not been a full-scale rethinking of how turnover data can be used, nor have there been attempts to accommodate or capture the new understandings of the relationships between population change, displacement, and inequality prevalent in urban studies literature.

Some studies have begun to categorize different types of turnover, based on the socio-economic status of the people moving in versus moving out (Robson et al., 2009; Travers et al., 2007), refining the metric in a way that begins to capture more of the nuances of population shift described above. Others have begun to question the value of turnover as the right metric for all applications, positing that a measurement of population retention is potentially more valuable for cities looking to assess certain qualities of their labor markets and communities (Borsellino et al., 2021). These studies begin an important trajectory to which this paper contributes; turnover alone can't capture the multi-faceted dynamics and knock-on effects of urban population displacement.

2.5 Study hypothesis

The goals of this study are to test two new metrics from already available data that better capture the nuances of physical and psychological displacement. These nuances are some of the critical components to measure in understanding the scope and scale of urban inequality that can result from aggressive urban development. As cities restructure and develop to both accommodate and accelerate this restructuring, where are existing residents remaining or being displaced, and what are their perceptions of these changes? What follows tests the relationship between two new proxy displacement metrics and measured turnover, and probes further into neighborhoods where new and existing metrics don't align, to discover if these new metrics can accurately identify resident perceptions of areas of unusual urban change.

3. Methods and data

3.1 Definition of the metrics

This section describes the standard measurement of turnover, and defines two new metrics designed to capture different nuances of potential population displacement.

3.1.1 Turnover

The most common metric to analyze people coming and going from an area is population turnover. This is a blunt measure defined by the number of people coming into an area plus the number of people leaving an area, divided by the total population, and often multiplied by 1000, to yield the rate of turnover per 1000 residents.

Population Turnover:
$$T = \frac{in(x) + out(x)}{pop(x)} * 1000$$

For the purposes of this research in Zurich, the units of area used (*x*) are the 34 city administrative units, called quarters (*Quartieren* in German). The quarters range from around 700 to 21,000 people in population size, and .23 km^2 to 7.47 km^2 in land area.

The total population inflow counts people moving from other city quarters, and from areas outside the city, both from within Switzerland and from abroad. The total population outflow counts people moving to other city quarters, to elsewhere in Switzerland, and abroad as well. The total population is the total number of people registering their primary home address in the quarter in the given year. The data is drawn from the official city population statistics described in the data section below.

3.1.2 Fresh Faces

The turnover metric as conventionally defined mutes the relationship between incoming and outgoing residents. This substantial flaw in turn mutes some of the most important shifts in neighborhood population from the perspective of existing residents. This study therefore creates two new metrics for describing population stability within the city to address this problem. The first will be called the Fresh Faces Ratio. This ratio calculates the number of people coming into an area, divided by the total number of people minus the outgoing people.

Fresh Faces Ratio:
$$FFR = \frac{in(x)}{pop(x) - out(x)}$$

While similar to turnover, and using the same three variables in the turnover calculation, this metric more accurately describes the relationship between incoming and outgoing residents of an area, calculating the ratio of new residents to existing residents remaining. From a mathematical perspective, an interesting aspect emerges in capturing this ratio. The incoming people play a first order (more powerful) role in the equation than the outgoing people (second order). This means that the ratio of new residents to existing residents remaining is much more strongly impacted by people coming than by people leaving. The face of the neighborhood changes more from new arrivals than from former residents moving out, perhaps accounting for some of why displacement is frequently felt and perceived more strongly than quantitative studies conclude (Brown-Saracino, 2017). This metric is similar to in-migration, but increasingly deviates from in-migration as the number of people leaving becomes more substantial.

When applied at the regional scale to moves in between municipalities within the greater Zurich region, this metric tracked turnover very closely. At the city scale, when tracking moves into and out of the city and between city quarters, the metric diverges more from turnover, capturing the power of newcomers in a neighborhood to make the neighborhood feel very different to remaining residents. This could potentially help explain why gentrification is perceived so strongly when there is a large influx of newcomers, even if the influx doesn't necessarily entail a large population being displaced at the same time.

The Fresh Faces Ratio calculates the ratio of new residents to old residents in the given area. This offers a more nuanced view of neighborhood make up than turnover, as it distinguishes between places with high population growth but stable existing population, places with high population decline, and places with balanced incoming and outgoing populations.

3.1.3 Replacement

Replacement has previously been theorized as an alternative term for the displacement caused by gentrification (Hamnett, 2003), diminishing the violence and instead alluding to a normal urban process. This research uses a calculated Replacement Index separate from that theory, to describe a phenomenon related to displacement but distinct in several key ways.

This metric measures how many incoming people replaced outgoing people, by counting every pair of one person coming in and one person going out, per 1000 residents in a given area (in this case the city quarters of Zurich).

Replacement Index:
$$RI = \frac{\min(in(x), out(x))}{pop(x)} * 1000$$

This is not a measure of displacement, as it makes no distinction between voluntary and involuntary moves away from the areas. It instead captures a potential upper bound on displacement by measuring the total replacement of old residents with new residents, as a fraction of the population. The above Fresh Faces metric aims to capture a quantitative measure that relates to the feeling of out-of-placeness, or perceived displacement. The Replacement Index described here serves as maximum number for physical displacement. Not all people who leave and are replaced by newcomers are forced to do so, and the nuances of defining a 'forced' move vs. an unforced one are complex (Atkinson, 2000; Davidson, 2009). Here I measure replacement as the total number of people replaced, regardless of reason for moving.

Similar to the Fresh Faces Ratio, at the regional scale the Replacement Index tracks very closely to turnover when studying moves in between municipalities, but diverges when studying moves into, out of, and between city quarters. While again using the same three variables as turnover and Fresh Faces, unlike turnover the Replacement Index distinguishes places where a higher percentage of existing residents are being replaced by newcomers from places with either high population growth or high population decline.

3.2 Data sources

This article draws on several different data sources, including population register data from the city of Zurich, a Zurich city survey, a self-generated survey of selected neighborhoods, and annual city records of completed new buildings and apartments. These sources are described below.

3.2.1 City of Zurich population register

Every resident of Zurich is required to register with their local district administrative office, which records the date of move into the district, and the previous district of residence (or municipality if outside Zurich city). When a resident moves, they are required to de-register from their quarter and re-register with their new location's administration, or, if remaining in the same quarter, to inform the local administration of the move. The city therefore has extremely detailed records of people moving in and out of each city quarter, which are collected and collated annually.

3.2.2 City of Zurich resident survey

The city of Zurich conducts a biannual survey on resident satisfaction, moving behavior, and perceptions of change in the city. The survey is conducted by the urban development and statistics office of Zurich. It was conducted by phone until 2015, and starting in 2019 was conducted online and in writing. The city surveys a representative sample of the city population of legal age, who are residents and have been registered in the city of Zurich for at least one year. The survey is offered in German, Italian, Spanish, Serbian-Croatian-Bosnian, Portuguese and English, and additionally in French in 2019. In addition to general demographic information, the survey requests socio-economic information (level of education, type of profession, income, rent paid), and also a number of questions on residents' satisfaction overall and with a number of specific aspects of living in Zurich, such as amenities provided, city administration, reasons for moving, housing cost burden, and neighborhood environment. Between 2500 and 3600 people are surveyed per year, and the results are weighted to better align with demographic attributes of the population at large. Until 2015, the survey data was grouped according to some individual quarters but collected data from some quarters combined together. 2019 was the first year results for each city quarter were reported individually, and over 5000 people were surveyed, significantly more than in previous years.

3.2.3 Self-generated survey

This study also conducted a survey of three case study neighborhoods in the summer of 2021. This survey adds to the Zurich resident survey by asking residents how long they had been in their neighborhood and whether they felt as though they belonged. The follow up interviews were also able to probe in further depth resident's feelings and reasons for belonging or not belonging where they lived. The case neighborhoods were chosen based on distinct profiles of neighborhood change from 2010-2016, and in each case the survey was given to residential areas with large new housing development from 2009-2012. 831 people received the survey. The neighborhoods were in the quarter Escher-Wyss, on Turbinenstrasse and Naphtastrasse, (primarily new construction), in the quarter of Fluntern around Mittelbergsteig, Freudenbergstrasse, and Forsterstrasse (one new development surrounded by older construction), and in the quarter of Altstetten around Badenerstrasse and Flurstrasse (a mix of old and new construction). The overall response rate was 17.9%. Forty-two respondents agreed to take part in follow up interviews.

The survey was administered by paper questionnaire via post and paid return envelopes, in order to minimize biases towards more digitally savvy respondents. The survey asked residents why they chose their current location; whether they felt their neighborhood was changing positively or negatively, and why; whether they felt they belonged in their neighborhood, and why; and whether they felt they were like or unlike their neighbors. The survey evaluated the direct answers to its questions, and provided a comparison opportunity between how people in the new construction and people in the already existing neighborhood feel about their environment, and their motivation for moving/residing in the area. The majority of survey questions were given with structured answer options, as well as room for individual follow up comments.

3.2.4 Additional City of Zurich data

The city of Zurich keeps track of new building statistics. This research uses city data, aggregated by city quarter, on new apartments constructed by year, new buildings with at least one apartment constructed by year, and apartment vacancy rates by city quarter. The research also uses annually collected data on taxable incomes from the tax office and the national origins of residents from the population register to detail the characteristics of the neighborhoods under study.

3.3 Mapping of metrics and identification of outliers

3.3.1 Turnover, Fresh Faces, and Replacement in Zurich

The maps in Figure 1 show the average Turnover, Fresh Faces Ratio, and Replacement Index for each city quarter from 2010-2020. At first glance, the geographic spread of the three metrics looks similar within the city of Zurich (Figure 1). All three metrics show the highest population instability at the densest parts of the city core, with instability decreasing in the quarters toward the city edges.
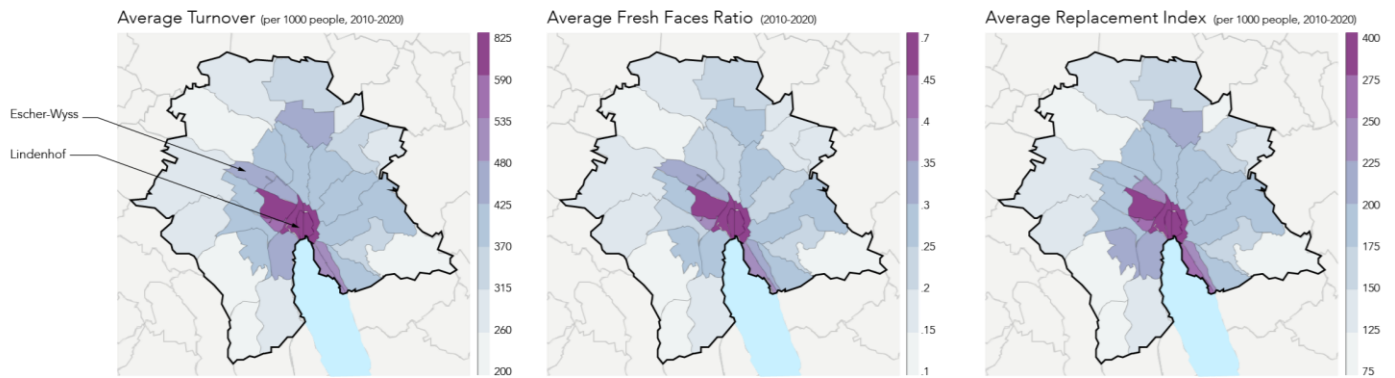
Figure 1: Maps of City Zurich with Average turnover, Fresh Faces Ratio, and Replacement Index shown by quarter, for 2010-2020. The classification method for these maps is a defined interval with an extended top and tail to accommodate outliers. The labeled quarters are the case study quarters referred to throughout the paper. *Source: Author, from Swiss Federal Statistic Office data*

3.3.2 Turnover and Fresh Faces

However, when studying the relationship between turnover and the new metrics, several outliers emerge. Figure 2 shows the relationship between turnover and the Fresh Faces ratio. Each dot represents one city quarter. As turnover increases, The Fresh Faces Ratio increases. The best-fit polynomial line on the graph indicates the presence of several outliers. When measuring the distance from each point to the best-fit line, Escher-Wyss and Lindenhof are more than three standard deviations further from the line than the other points. In these quarters the ratio of new to existing residents was significantly higher relative to turnover than in any other quarter.
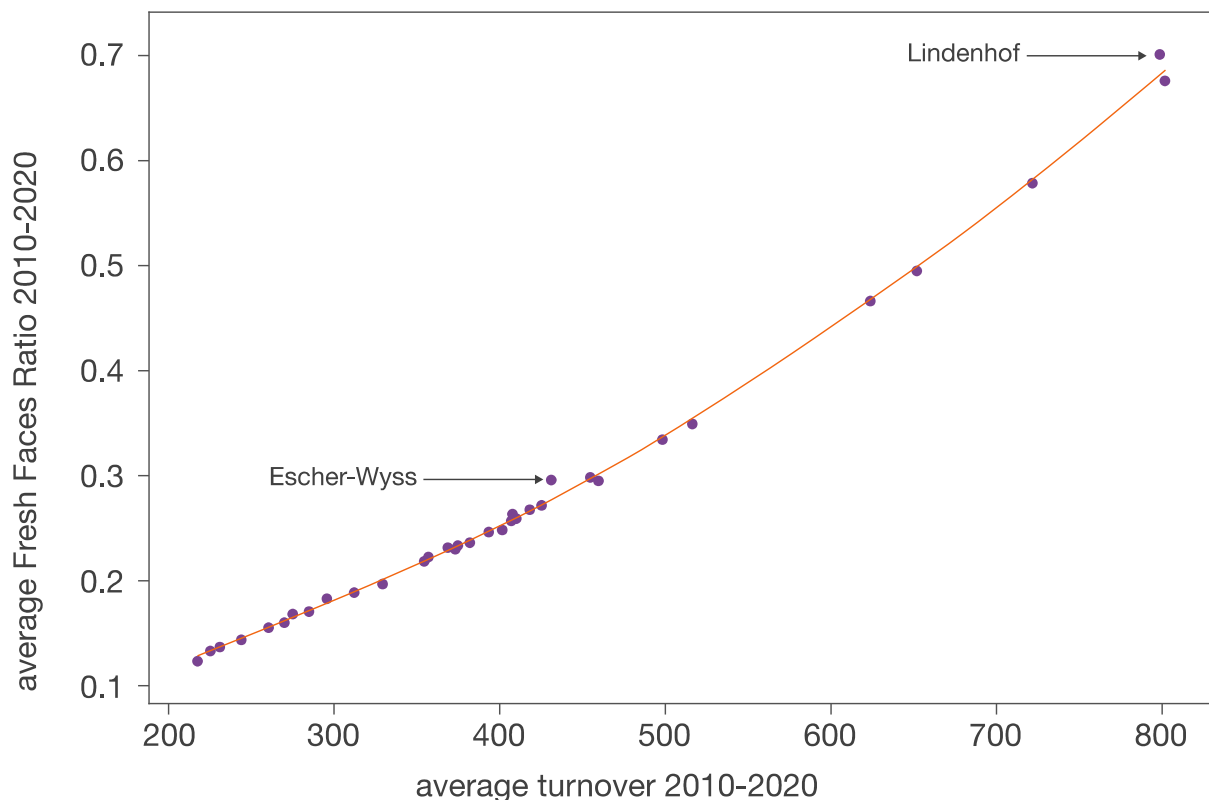
Figure 2: Average turnover plotted against average Fresh Faces Ratio by city quarter, for 2010-2020.
Source: Author, from Swiss Federal Statistic Office data

3.3.3 Turnover and Replacement Index

Plotting average turnover against the average Replacement Index by city quarter yields a clear best fit line with an evident outlier (Figure 3). When measuring the distance from each point to the best fit line, Escher-Wyss is more than four standard deviations below the line. Escher-Wyss, therefore, had a higher ratio of new to old residents compared to its turnover rate, and significantly less replacement of existing residents than might be expected from measuring turnover alone.
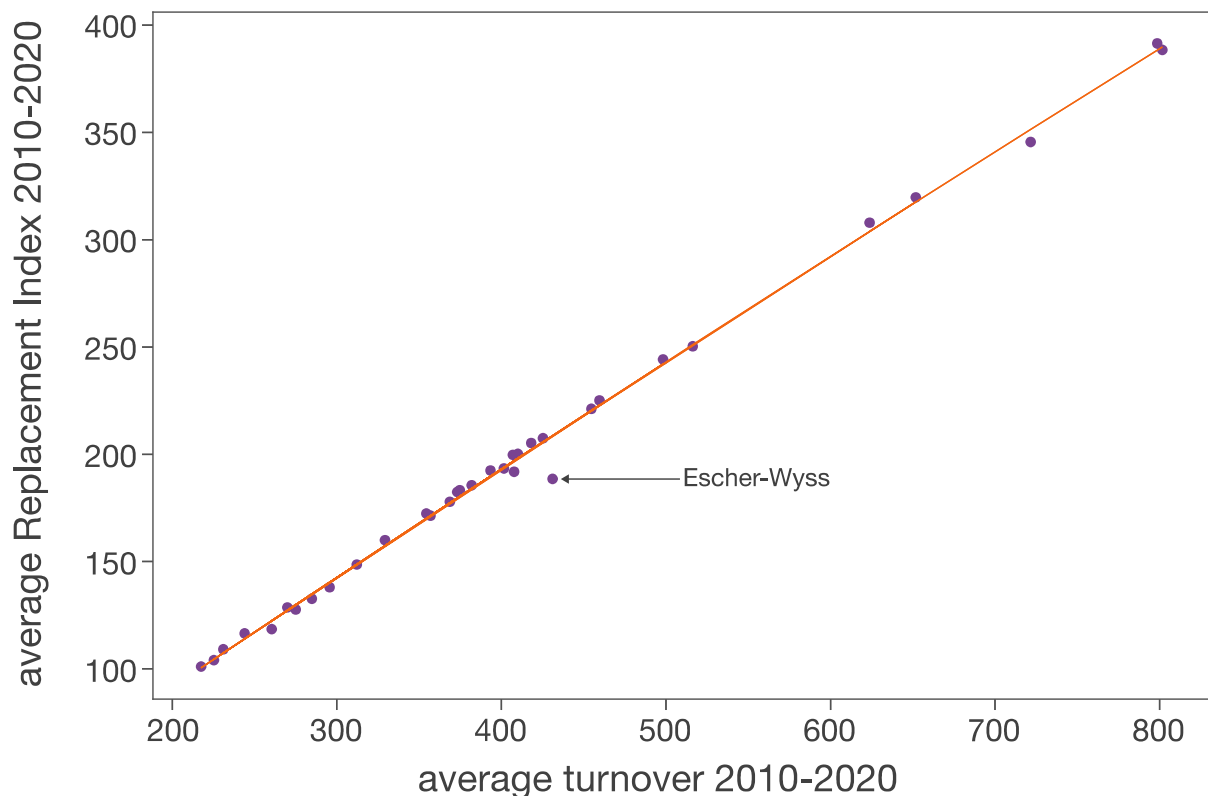
Figure 3: Average turnover plotted against average Replacement Index by city quarter for 2010-2020.
Source: Author, from Swiss Federal Statistic Office data

3.4 Assessing outlier neighborhood quarters

Following the identification of Escher-Wyss and Lindenhof as outlier neighborhoods by population change type, the study researched several additional characteristics of these neighborhoods compared to other quarters and city-wide averages. The biannual Zurich resident survey asks residents "How has your immediate living environment changed recently?" (recently taken to be the last five years), and allows respondents to choose "rather positive change," "no change," or "rather negative change." This study analyzes the percentage of respondents selecting each type of change for each quarter in the city, comparing them to each other and to the city average. It uses the 2019 survey results, with a sample size of 5,117 respondents.

Additionally, the study's self-generated survey asked residents if they felt they belonged in their neighborhood, offering "yes," "somewhat," "neutral," "somewhat not," "no," and "not sure" as possible answers. The survey and follow up interviews then asked residents to discuss their reasons for belonging or not belonging. This study compares how strongly on average residents felt they belonged in the neighborhoods surveyed, and creates word clouds of the most frequently used words in the reasons given for belonging. This qualitative data adds a helpful explanatory lens to why the quantitative data might be showing the patterns it produces. Corroborating the quantitative findings with more labor-intensive qualitative understanding is a critical check on the validity of the proposed metrics, and whether they might be reusable elsewhere where such additional data is not available.

Finally, the research analyzes the average percentage growth or decline in total flats per city quarter from 2010 through 2020, using annual flat construction statistics kept by the city of Zurich.

4. Results, discussion, and limitations

4.1 Results

The analyses described above indicate four distinct results: identifying outliers in turnover's relationship to Fresh Faces and Replacement; understanding awareness of and satisfaction with neighborhood change for residents in outlier areas; interpreting residents' descriptions of change and belonging in one outlier neighborhood; and correlating these findings with the outlier neighborhoods' built environment characteristics.

Identified outliers: The first result finds turnover to have a very consistent relationship to both the Fresh Faces Ratio and the Replacement Index in all but one outlier quarter for both, and two outlier quarters for Fresh Faces. The quarter of Escher-Wyss was an outlier for both metrics, and the quarter Lindenhof the outlier only for turnover's relationship to Fresh Faces.

Awareness of change: The second result finds that in both Escher-Wyss and Lindenhof, residents had strong perceptions of change in their quarters, and strong opinions on whether that change was positive or negative. The city-wide percentage of residents who saw no change in their

quarter of residence was 50.9%. It was lower in Lindenhof, at 44.9%, and significantly lower in Escher-Wyss. In Escher-Wyss, 23.1% of residents saw no change in their neighborhood, more than two standard deviations below the mean for all quarters.

City-wide, 28.2% of residents saw positive change in their neighborhoods. This number was lower in Lindenhof, at 18.6%, and much higher in Escher-Wyss. In Escher-Wyss 59.3% of residents saw positive change in their neighborhood, more than three standard deviations above the mean. In the self-generated survey conducted in 2021 in a small subsection of Escher-Wyss, the percent of residents seeing positive neighborhood change in the last five years was 75%.

The results for residents' perception of negative change similarly highlighted the outlier quarters. The percentage of residents who saw negative change city-wide was 20.7%, while in Lindenhof it was 36.5%, more than two standard deviations above the mean. 17.7% of Escher-Wyss residents saw negative change in their neighborhood in the last five years, lower than the city mean.

Perceptions of belonging: Results from the self-generated survey and follow up interviews further elicit how residents in Escher-Wyss perceive neighborhood change. Of the three neighborhoods surveyed, the neighborhood in Escher-Wyss reported a lower feeling of belonging than in the other two neighborhoods. In Escher-Wyss the average answer to whether a resident felt they belonged in the neighborhood was between 'neutral' and 'somewhat,' while the other two neighborhoods were between 'somewhat' and 'yes.'

The variation in feelings of belonging is further elaborated by the reasons people gave for feeling like they did or did not belong in their neighborhoods. Figure 4 shows the most common words residents in Escher-Wyss used in the survey and interviews to describe why they felt they did belong, on the left, and why they felt they did not belong, on the right.

Figure 4: Most common words to describe belonging (left), and not belonging (right). Some responses were in English and some were in German, and the German responses have been translated into English for the purpose of this word cloud, which shows the most frequent response words used in the largest font size. *Source: Author, from self-generated survey and interviews*

The words most frequently used by people who did and did not feel they belonged were strikingly similar. Most often the neighborhood was described as anonymous, with very little contact or interaction with neighbors beyond elevator greetings. Some people who felt they belonged described this anonymity as very positive attribute, and some people who both did and did not feel they belonged described it as a negative attribute. The positive reasons given were usually a desire for anonymity in the choice to move to the area, part of a desire to live in the city and be able to be unknown and live independently. While many cited the anonymity as a good thing, several noted it as something they did not care about one way or another, and several said it contributed negatively to the neighborhood.

Urban development in outliers: Lindenhof and Escher-Wyss represent opposite ends of the spectrum for new housing construction from 2010 to 2020. Lindenhof added or removed on average one to two apartments per year during this time period, for an average annual housing stock growth of 0%. Escher-Wyss had an average annual housing stock growth of 6%, more than doubling the quarter's existing housing stock from 2010 to 2020.

4.2 Discussion

The above results describe two very different trajectories for the quarters where the Fresh Faces Ratio and the Replacement Index deviated significantly from turnover. Lindenhof is one of the smallest quarters in the city, by both population and land mass, and incorporates much of the old medieval city core. It has one of the highest rates of turnover in the city, with a very small long-term population. That the Fresh Faces Ratio in Lindenhof was higher relative to turnover than other city quarters is likely due to the significant short-stay population in the area. The Replacement Index value suggests that a small core of residents remain in the area long term, while a significant percentage of the neighborhood turns over frequently. The revolving door of new faces may account for the strong perceptions of negative change in the quarter; cities around the world struggle with impacts of short-term rentals on local communities, and Lindenhof could be grouped with this trend.

Where average incomes in the city overall increased between 2010-2020, in Lindenhof they declined slightly, just outside one standard deviation of change for all the city quarters. The percentage of foreign residents in Lindenhof also increased over the time period, by less than the city overall but within the standard deviation for all quarters. While the city's average age increased during this time period, the average age in Lindenhof decreased, more than two standard deviations outside the mean. This reinforces the idea of the core resident population staying somewhat consistent, while an increasingly younger and mobile short-stay demographic is moving through the neighborhood regularly.

Escher-Wyss had a low-middle turnover rate compared to other city quarters. It is the former industrial quarter of Zurich, which in the past two decades has exploded with new development of housing, commercial, and mixed-use construction. The deviation of both the Fresh Faces Ratio and the Replacement Index from turnover compared to other quarters here signifies processes taking place that are exceptional within the context of Zurich city. While Escher-Wyss's turnover is unexceptional, the new metrics capture something happening that is evident to residents of the neighborhood. An exceptionally high number of residents registered the changes taking place in their environment, and an overwhelming majority of those who registered change perceived the change to be positive.

In Escher-Wyss average incomes increased more than three standard deviations beyond the mean between 2010 and 2020. Escher-Wyss because slighty more Swiss and less foreign, just above one standard deviation for the change in all quarters. It also became slightly older, in line with the city and individual quarter mean. Despite the large jump in average income, typically consistent with concerns about displacement, the residents of Escher-Wyss, both new and old, report a high degree of satisfaction with their neighborhood.

One key difference between Escher-Wyss and Lindenhof is that Escher-Wyss deviated from turnover significantly in the Replacement Index, as well as Fresh Faces. While the Replacement Index captures all replacements of old residents with new, ignoring any distinction between forced or voluntary moves, a low replacement number likely indicates a lower overall number of forced physical displacements as well, or at very least an existing population more able to stay in place. The ability of existing residents to stay in place could certainly contribute to the exceptionally high percentage of residents satisfied with the change taking place in their neighborhood.

Residents who felt they belonged and residents who did not all cited the anonymity of the neighborhood. While in other neighborhoods surveyed, anonymity was cited infrequently and when cited, cited purely as a negative attribute, in Escher-Wyss a different perception was pervasive. This attitude toward anonymity in Escher-Wyss ruptures the narrative that the weak social ties associated with increased population change are necessarily undesirable, or a social ill. This outlier attitude towards anonymity corroborates that the new metrics perhaps captures some qualitative nuances of how people perceive their urban environment.

The significant positive attitude found toward change in Escher-Wyss, where replacement was exceptionally low despite turnover being average, indicates that residents' ability to stay in place, despite an influx of new people, was critical to satisfaction with their neighborhood. In the service of better documenting displacement as a key urban inequality, detecting its extents, and potentially mitigating its effects, these new indices have potential to identify likely areas quickly, without extensive data collection or sophisticated tools. While the science of measuring displacement has a long way to go, and will always require in-depth site and context specific research, a quick measure for early identification of areas undergoing extensive or unusual change would contribute to filling the gap in understanding both physical and psychological displacement quantitatively.

4.3 Limitations

The potential to replicate the use of the Fresh Faces and Replacement metrics in new contexts outside of Zurich is substantial, as the data to measure turnover are typically already available in some form. However, it is important to note several limitations to the study, in large part driven by the Swiss context. While the metrics may be replicable, the Zurich specific findings are not intended to be taken as necessarily applicable to other contexts. Zurich is a small city, only about 405,000 people within its political borders. While Swiss residents may find anonymity and refuge in urban Zurich, Zurich might feel like a small village to residents of Moscow or Istanbul. Additionally, there are significant protections for tenants' rights in place in Switzerland, that differ across different national contexts. Because of this, turnover and Fresh Faces or Replacement may track more or less closely together in other cities, for differing reasons. While the broad metrics work to determine areas of interest, an in-depth exploration of local regulatory and cultural contexts would be necessary to ascertain why population changes happen or are perceived in certain ways for specific areas. These metrics are not meant to serve as universal truths, but rather as useful benchmarks to begin identifying areas of additional interest and study.

A full-scale assessment of the spatial correlations to displacement including new construction and other socio-economic factors within Zurich does not fall with the scope of this article, as the intent is to assess how effective the new metrics are at identifying areas of unusual change. A more rigorous analysis of Zurich's population changes using tools such as Geographically Weighted Regressions would be an excellent future study to further understand why and how some of the population changes in Zurich specifically are taking place.

Another limitation of the research is that the response rate of the self-generated survey was relatively low. However, the sample of both survey respondents and interviewees was representative of the demographics and socio-economic statistics for the overall quarter.

5. Conclusions

Turnover is an old metric that has not been critically rethought since its introduction in the early twentieth century. While a good proxy for studying many aspects of population change, it obscures some of the critical aspects of population change that contribute to urban inequality and are frequently prevalent in tandem with urban development. The aim of this paper was to test if commonly available turnover data could be refashioned to measure fundamental attributes of urban inequality, such as displacement. By using Zurich as a test case, the research demonstrates that two new metrics can capture aspects of urban displacement that align well with resident perceptions of population change. This is alignment between the measurement and perception is critical for extending the existing literature on quantifying displacement. The noted problem that qualitative and quantitative methods for studying displacement often yield contradictory results (Brown-Saracino, 2017) can perhaps be addressed through metrics where the outcomes are better aligned.

Additionally, the new metrics presented in this paper are easy to reproduce across varied data contexts. If data are available to measure turnover, which they often are, they are available to measure both the Fresh Faces Ratio and the Replacement Index of given areas. Given the increasing drive to standardize data across Europe (Bartha & Kocsis, 2011), these new metrics also offer new tools for comparative international study. Expanding this study to other cities in Switzerland, as well as urban areas in other countries, would continue to test the value of the metrics in identifying areas undergoing exceptional population changes. Measuring how these metrics relate to turnover, and where they are higher or lower than might be expected, can highlight areas where distinct and unusual phenomena might be taking place. While at best they are only proxy measures for the perceived and physical aspects of displacement, in combination with turnover they better capture this specific barometer of urban inequality than turnover alone, and can indicate areas requiring further study and follow-up analysis, even in environments where limited population data is available. As more and more data to understand population movements are available via new technologies, the wider applicability of these tools might also increase. A relatively simple tweak to a standard measure offers a quick, comprehensive, and illuminating comparison between urban areas, serves to better identify outliers, and may guide researchers to where populations are undergoing exceptional forms of change.

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