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Adaptability of Urban Grids: Patterns of Morphological Change and Persistence in Midtown Manhattan, 1884-2011

Onur Tumturk[1], Prof. Justyna Karakiewicz[2], Dr. Fjalar De Haan[3]

[1] Melbourne School of Design, Faculty of Architecture, Building and Planning, University of Melbourne, Australia

[2] Melbourne School of Design, Faculty of Architecture, Building and Planning, University of Melbourne, Australia

[3] Centre for Integrative Ecology, School of Life and Environmental Sciences, Deakin University, Australia

Abstract

Urban grid, as an open framework and an adaptable form of spatial organisation, has a capacity to produce infinite complexity and variety through time. This research is about the morphological conditions that affect the generative capacity of urban grids. Arguing that there could be distinctive morphological settings and conditions that may hinder or facilitate further adaptation and change, the research aims to develop an analytical framework to identify possible morphological variables affecting the patterns of change and persistence in the built environment. The study focuses on the Midtown Manhattan, the central part of Manhattan's extensive grid, and traces the morphological changes and continuities between 1884 and 2011 by relying on a comprehensive spatial database. The longitudinal analysis of the site reveals that different characteristic areas in the grid (in terms of plot compositions, syntactic values of the streets, diversity of land uses) show different patterns of change and levels of adaptation to emerging disturbances through time. Identification of the reliable morphological parameters explaining the capacity of spatial change and persistence will contribute to the emerging discussions on the resilience and adaptability of urban form.

Keyword: *adaptability, resilience, urban grids, morphological change, persistence*

Introduction

Cities are complex adaptive systems manifesting various transition patterns and their form and structure are shaped by the accumulation of many interests and disruptions through time. The complexity and unpredictability of these divergent dynamics make empirical analysis of morphological change a challenging issue. Rossi (1982: 55) argues that *"the city is something that persists through its transformations"* and illustrates that the resilience of the urban space could only be achieved with a dynamic relationship between permanent and transformative artefacts. To that end, this research aims to develop an analytical framework to examine patterns of morphological change and identify possible morphological parameters affecting the levels of change and persistence in the built environment.

Without denying the promises of different spatial systems in different circumstances, grid, or gridiron, is acknowledged by far the most common and adaptable form of spatial organization, which is both persistent through time and allowing various spatial changes which are not imagined before (Martin & March, 1972; Kostof, 1991; Busquets, 2019). Grid, as an open framework, has a capacity to produce infinite complexity and variety from a very simplistic pattern and it persists through time by regulating emerging changes in the urban space. However, it does not mean that any grid is inherently adaptable and responsive to change.

Arguing that there could be distinctive morphological settings and conditions that may hinder or facilitate further adaptation and change, the research asks the question of ‘how do morphological conditions of the grid affect the levels of change and persistence over time?’. Being part of a larger and ongoing comparative study on different grid cities (Barcelona, Melbourne and New York), this research focuses on Midtown Manhattan, the central part of Manhattan’s extensive grid, and traces the morphological changes and continuities between 1884 and 2011 by relying on a comprehensive spatial database. The longitudinal morphological analysis of the site will be discussed together with the identified morphological variables in order to understand the effect of initial spatial conditions on the patterns of change and persistence.

Background: Conceptions of Change and Persistence in Urban Morphology

Within the field of urban morphology, there are various studies focusing on the patterns of change and persistence and their relationship with form and morphology of the urban space. While Moudon’s (1986) study on Alamo Square demonstrates the relationship between plot composition and level of change, Siksna’s (1998) extensive study on the size and composition of urban blocks illustrates the effect of block size on the patterns of change and persistence. In the last years, there has been some other studies trying to incorporate space syntax techniques with the morphological studies to understand the effect of street configuration on procedural change, especially in suburban neighbourhoods (Torma, 2017; Hallowel & Baran, 2020). In addition to the effects of compositional and configurational variables on spatial change, Vaughan et al. (2015) discussed the effect of spatial diversity on the patterns of functional change and demonstrated that *“the greater the diversity of land uses, the more likely it* (the street) *is to generate different sorts of activity by different sorts of people”* (p.18).

A brief review of these studies shows that most of the research focus on suburban developments or neighbourhoods having slower dynamics of change comparing to central areas. Therefore, it could be more straightforward to explain morphological change by relying on a single or a few variables in these areas. However, central parts of cities which have experienced more complex transition processes may require different measures to explain physical and functional changes in these highly dynamic areas. Moreover, some of these studies present controversial results about the effect of some morphological variables on change and persistence – which means there is a clear need of further research for a more unified understanding of the issue, especially for the city centres. Identification of the reliable morphological parameters explaining the capacity of spatial change will contribute to the time-wise understanding of urban space (Porta & Romice, 2014) and open up new discussions on the resilience and adaptability of urban form.

Methodology

The most fundamental units of the urban form are plots, buildings and their uses and streets – which are combined and scaled up to form the urban space progressively as a complex whole. In that sense, Marshall

(2009: 79) highlights the potential of street as *'a composite unit'* which is combining plots, buildings and routes. Therefore, in addition to the fundamental morphological units, 'street-block' will also be used as a composite unit in our morphological analysis. As it is discussed earlier with respect to the brief literature review, the model includes three different layers or morphological variables having hypothetical effect on the patterns of change and persistence: (1) configuration of street network; (2) composition of plots (3) spatial distribution of land-uses. In addition, morphological change is conceptualized in the model with respect to the variables of (a) physical change and (b) functional change along street-blocks.

The first morphological variable is the configuration of street network to measure topological values of segment integration value for each street segment. Space syntax analysis, performed in DepthMapX software (Varoudis, 2011), calculates various topological values for each street segment of the network. While integration value represents how close the origin segment is to all other street segments; choice value represents the potential of through movement along a segment. The second variable is related with the composition of plots which aims to measure the size of individual plots and their spatial distribution in the grid. The categories of plot sizes are defined by considering the original plot size (250m^2) in Manhattan and identified as small (250-500m^2), medium (500-2000m^2) and large (above 2000m^2). The third variable is the distribution of land-uses and functions to measure diversity of each street-block in terms of land uses by using Gini-Simpson Index and named as street-block diversity. The land uses will be categorized as follows: (a) residential, (b) mixed: residential & retail, (c) retail store, (d) offices, (e) public, (f) leisure, (g) manufacture, storage, warehouse (h) carpark & garage.

In addition to these morphological variables, two types of measures will be discussed to understand the amount of change in the built environment - the amount of physical change and functional change per street-block between each period of time. Excluding minor modifications and alterations of the buildings, physical change represents change and transition in built form via demolition and construction of the buildings. On the other hand, functional change is defined as the transition of the use of a building from one land-use category to the other, without changing physically. It represents the adaptive capacity and responsiveness of the built form for different land-uses.

The analysis area covers one of the central locations in Manhattan, named as Midtown, and it shows diverse and dynamic patterns of morphological change since 19th century. Physical and functional changes will be mapped via diachronic comparison of the digitized cartographic maps (obtained from the New York Public Library Digital Collections of Maps & Atlases) for the years of 1884, 1920 and 1956 respectively, and one of the most recent GIS data (obtained from New York City Department of City Planning PLUTO datasets) available for 2011. The morphological transitions between each analysis period will be presented along with the identified morphological variables. Possible relationships between some of the morphological variables and physical and functional changes will be discussed critically.

Results and Discussions

For the first morphological variable, *configuration of street network*, space syntax analysis was performed to measure topological values of street segment integration for the radius of 2500 meters (Figure 1). In space syntax terms, value of spatial integration represents the potential of street segments for movement and defines the level of *"essential urban dynamic by which grid structure, movement, land-use patterns and densities become interrelated"* (Hillier, 1999: 177). Therefore, theoretically, it would not be wrong to argue that higher segment integration values may be one of the critical morphological conditions for the patterns of physical change over time. After 1880s, street structure of both Manhattan and Midtown doesn't change dramatically, but integration values increase gradually as a result of the emerging connections to the surrounding boroughs of New York. What is particularly consistent in Midtown through each period is that the streets having the highest integration values are the wider boulevards oriented in north-south direction and also 42nd Street which is the most important east-west oriented street in Midtown.

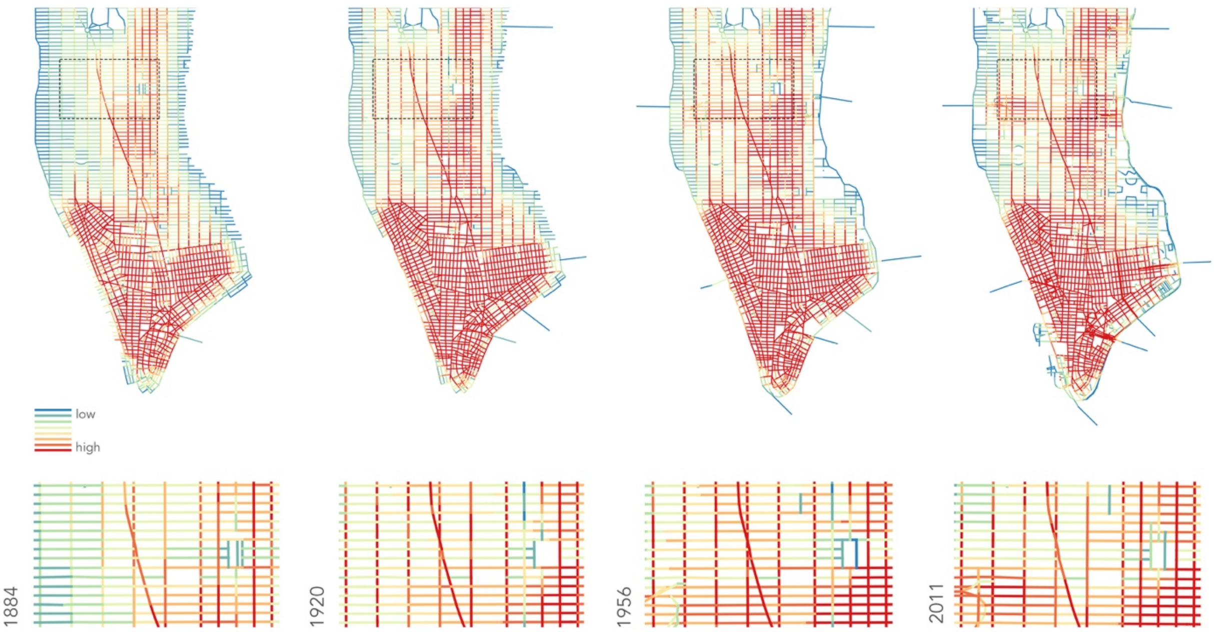

Figure 1. *Segment angular analysis of the integration (2500m) for Midtown, Manhattan*

Diachronic comparison of the built form in each period illustrates that patterns of physical change usually tend to cluster along particular avenues having relatively higher average segment integration values (Figure 2). In the first period (1884-1920), most of the physical changes in the built form concentrated along Broadway, 7th Avenue, 5th Avenue and 42nd Street and the very adjacent street blocks to these streets. More than 50% of these street blocks transformed physically in the first period. Another particular finding is that although 3rd, 6th and 9th Avenues have high average segment integration values as similar to the other north-south oriented avenues, they are conversely the most persistent street blocks. The reason behind this controversy is that elevated railways were present along these axes as the first rapid-transit system of the city. Argued by Stern et al. (1999: 78), elevated railways led to the environmental issues, because trains along these lines were quite noisy and steam was disturbing for both the inhabitants and retailers. In that sense, it could be argued that this special mode of transport discouraged further physical change and development of the built environment along these streets even if they have high segment integration values. In the second period (1920-1956), most of the physical changes in the built form concentrated along the Park, Lexington and Madison Avenues and the very adjacent street blocks to these streets which have the highest segment integration values and more than 50% of all street blocks were re-built. Reconstruction of the Grand Central Station as a major transportation hub in 1913 and removal of the rail tracks along Park Avenue have contributed to this pattern of physical change as well. In the third period (1956-2011), most of the physical changes occurred along 6th Avenue after the demolishment of elevated railway and 42nd Avenue's western part which started to become more integrated with the construction of Lincoln Tunnel and a regional bus terminal in the second half of the century. As similar to the 6th Avenue, 3rd Avenue were re-built mostly within this period after the removal of elevated railway infrastructure.

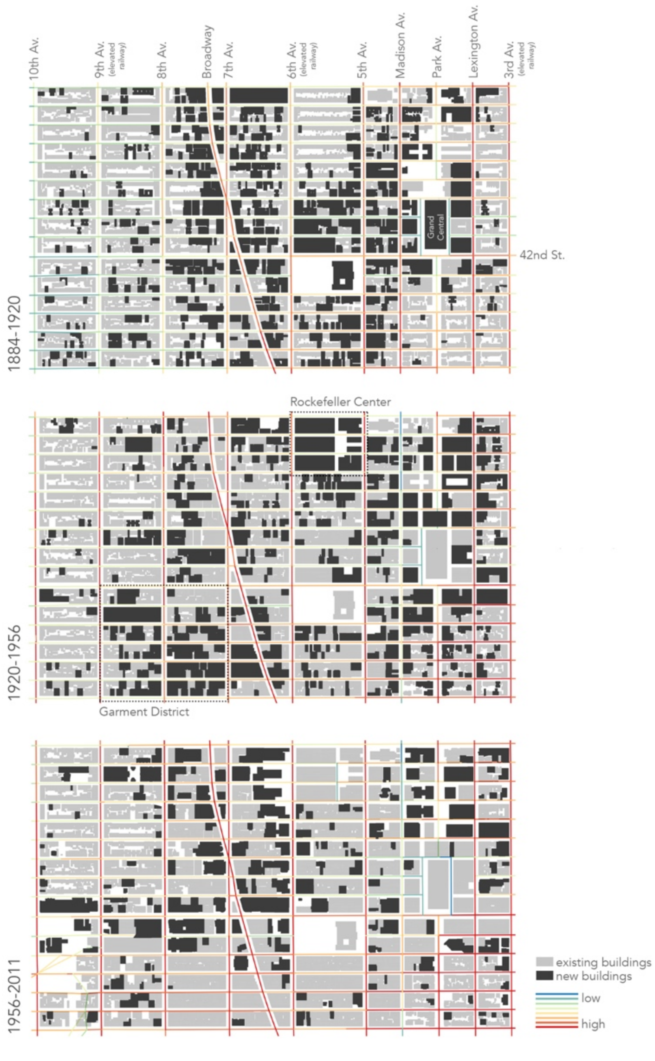

Figure 2. *Patterns of physical change in Midtown, Manhattan between 1884 and 2011*

The relationship between the configuration of street network and physical change illustrates that streets having the higher segment integration values have a potential to propagate more physical change, because in each period most of the physical changes concentrated along topologically more important streets. However, it does not mean that there is a linear relationship between higher segment integration and the amount of physical change. While specific modes of transportation like elevated railways may discourage physical change, emerging attractors like transportation hubs may lead to an unexpected increase in the amount of physical transformation and development. Therefore, it could be argued that the configuration of the grid provides a conditional potential for physical change if the other conditions are satisfied as well. Conceptualised by Hillier (1999) in a similar way, if the structure of the grid is equally loaded with forms and uses, it creates a field of potential for interaction, urban dynamics, land-uses and densities, *"though not in linear form"* (p.177).

For the second morphological variable – *composition of plots* – and its relationship with the amount of physical change, plots accommodating physical change have been identified and mapped for each period (Figure 3).

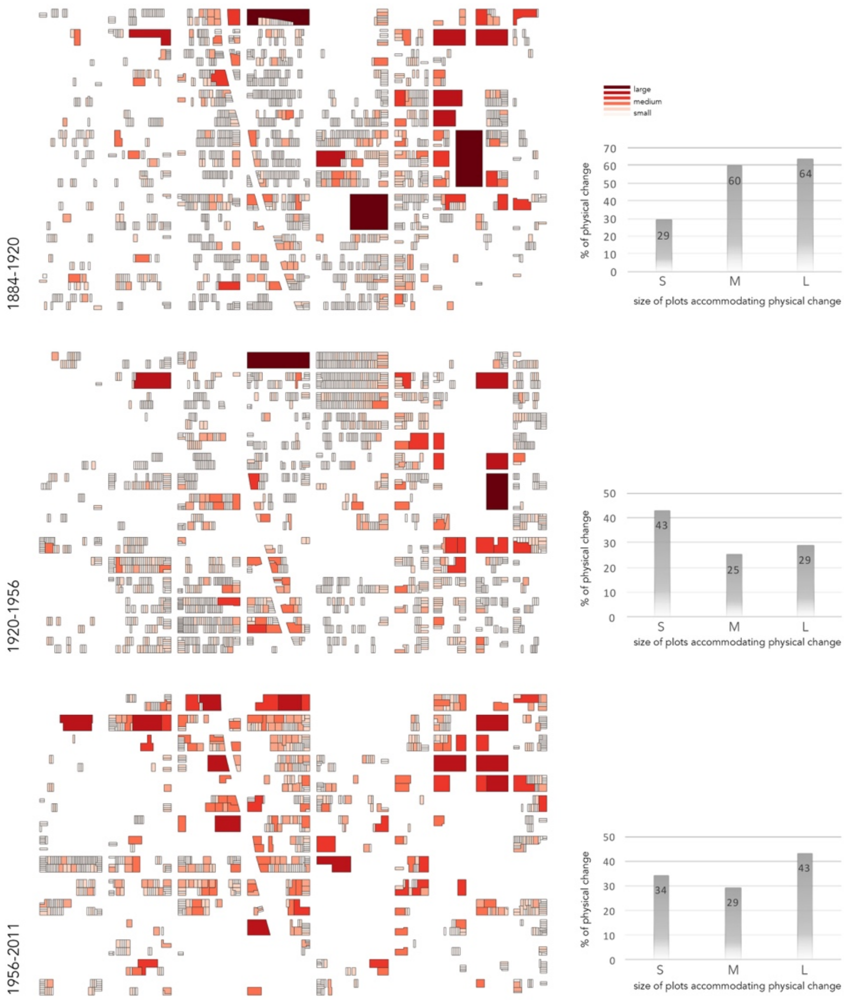

Figure 3. *Distribution of the size of plots accommodating physical change in Midtown, Manhattan*

Both in the first (1884-1920) and third period (1956-2011), small plots are more resistant to physical change comparing to the larger ones. Although the number of larger plots are comparatively less, their frequency of accommodating physical change is higher than the smaller ones. It shows that larger plots which are usually occupied by larger building footprints tend to be demolished and rebuilt in each period, especially along the Park Avenue in Midtown. Since the amalgamation of individual plots, especially in city centres, requires more effort and cost, physical change and development occur mostly on these larger parcels which are already amalgamated to be built with larger built forms. Contrary to that, in the second period (1920-1956), small plots accommodated more physical change comparing to the medium and larger ones. The reason behind this contradiction is the top-down and large scale planning interventions leading to the loss of many small plots especially in this period. After 1916 Zoning Resolution of New York City, today's Garment District has been designated as an 'unrestricted use zone' and the area has transformed into an industrial district via the amalgamation of original and small Manhattan plots to build bigger loft buildings. In addition to that, Rockefeller Center was built in the same period by erasing more than two-hundred plots in three urban blocks at once to acquire a large super-block. Excluding the exceptional effect of large-scale planning and design interventions in this period, it could be argued that small plots are more resistant to physical change and this finding supports some of the previous research (Moudon, 1986; Hallowel & Baran, 2020).

For the third morphological variable – spatial distribution of land-uses – Gini-Simpson Index is used to measure the level of functional diversity for each street block. The categories of land-uses are identified according to the available data of building uses on historical maps and a dominant category of use is assigned to each building for all periods. In 1884, Midtown Manhattan was mostly a residential district, including retail stores at ground floors of north-south oriented wider street-blocks. Functionally the most diverse street blocks were Broadway, 7th Avenue, 42nd Street and 5th Avenue and they were exactly the same street blocks propagating higher percentage of physical change in the following period until 1920s. In the second period, in addition to these streets, the level of functional diversity increased in the eastern part of Midtown, along with Madison, Lexington and Park Avenues. It is evident from the maps of physical changes that most of the physical transformations in the following period occurred along these functionally diverse street blocks. However, some of the important physical changes (emergence of Garment District and Rockefeller Center) of this era have occurred in relatively less diverse areas. As it is discussed above, this situation could be explained with the effect of top-down and large-scale planning interventions emerged after 1916 Zoning Resolution. In the last period, most of physical changes concentrated along the least diverse street blocks. Especially, the underdeveloped and ignored street-blocks of 6th and 3rd Avenues have been rebuilt after the removal of elevated railways, even if they are relatively less diverse than the other street blocks. The findings about the relationship between functional diversity and physical change illustrates that functional diversity could be a valid variable to explain physical changes emerging gradually in a bottom-up manner without the effect of large scale planning interventions. While the level of functional diversity clearly correlates with the amount of physical changes in the first period, it gradually loses its validity in the second period and become invalid to explain physical change in the final period. In terms of the functional transformation, the most consistent pattern is the gradual decrease in functional diversity and homogenization of land-uses along the most diverse street blocks in Midtown (Figure 4).

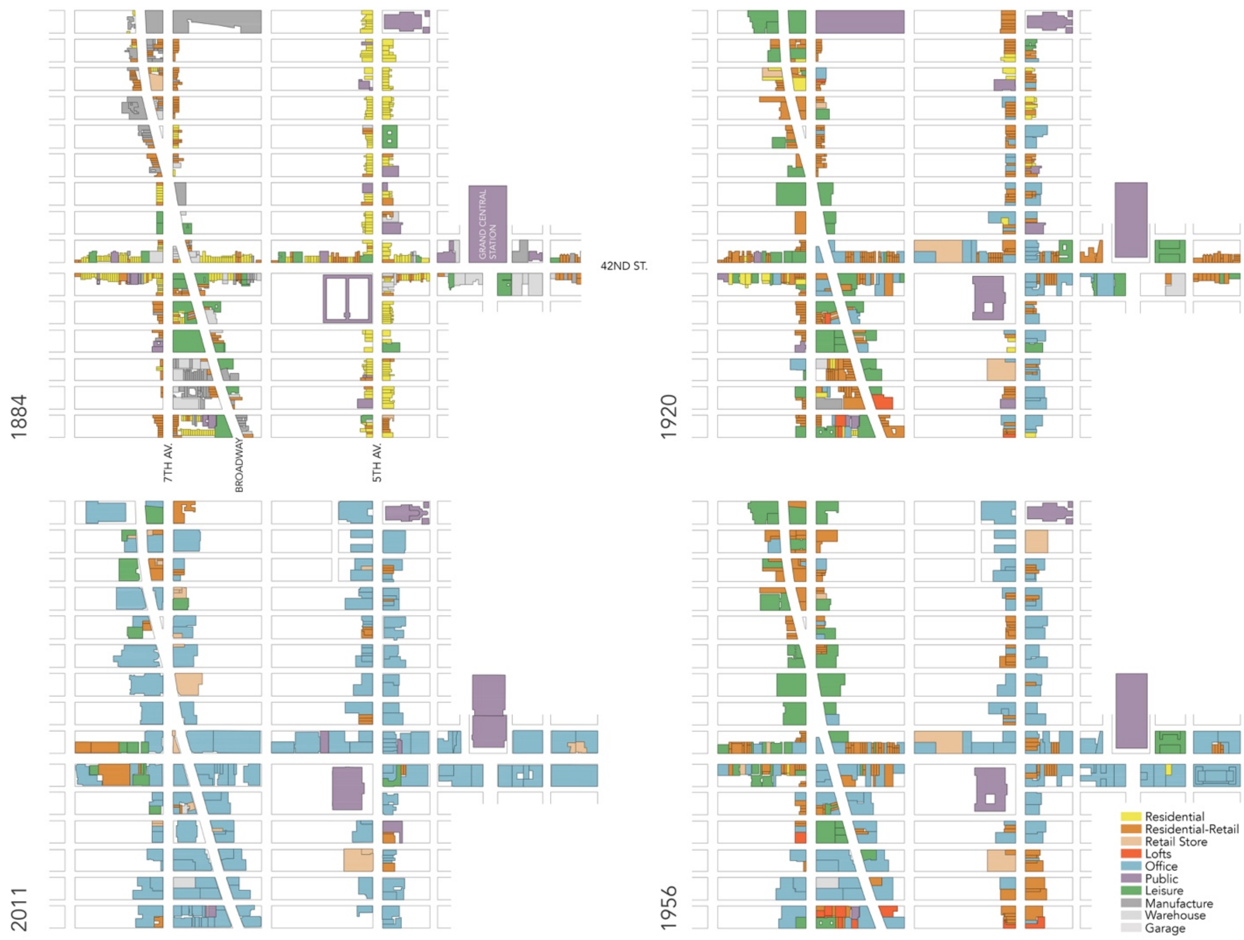

Figure 4. *Transition of the spatial distribution of land-uses along the most diverse street-blocks in Midtown,Manhattan*

In addition to the relationship between morphological variables and physical change, patterns of functional change deserve to be discussed further. Contrary to the patterns of physical change, functional changes between each period seem to occur in a more dispersed manner through the whole grid instead of clustering along certain street blocks. It shows that functions and uses are more dynamic and transitionary than built form. In that sense, morphological variables of the configuration of street network and diversity of street-blocks couldn't explain functional changes, but the variable of plot size seems a quite successful predictor of functional change. For all periods of analysis, small and medium size plots have accommodated functional changes more successfully than the larger ones (Figure 5). In the first period, most of the functional transitions are between the categories of residential and retail uses, and small and medium size plots perform equally better than the larger ones. In the second and third periods, most of the functional transitions in

Midtown are towards the office uses and medium size plots accommodates most of these functional changes. The analysis shows that larger plots couldn't accommodate functional changes as much as the small and medium ones; because, as it is discussed previously, larger plots tend to be physically changed more often. Since the relatively big and bulky buildings on larger plots are usually designed for specific functions – which is a clear spatial manifestation of the so-called 'form-follows-function' approach – they have to be demolished and re-built each time to accommodate different programs and couldn't respond functional transitions.

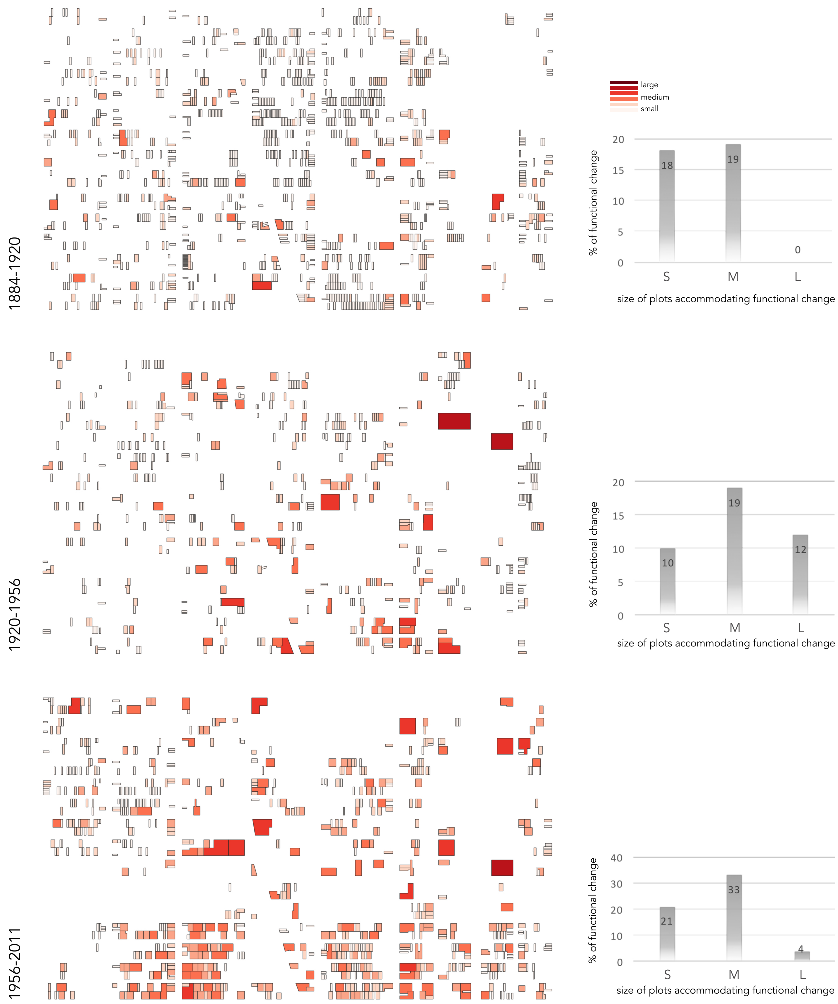

Figure 5. *Distribution of the size of plots accommodating functional change in Midtown, Manhattan*

Conclusions

The findings of this ongoing research illustrate that different characteristic areas in the grid manifest different patterns of change and persistence over time and most of these patterns could be explained with the identified morphological variables. In terms of the configuration of the street network, streets having higher segment integration values have a potential to propagate more physical change if the other conditions are equally satisfied as well. Functional diversity of a street-block could be a valid variable to explain emerging physical changes without the effect of large-scale planning interventions. Until 1916 Zoning Resolution, the first comprehensive planning of New York, most of the physical changes were clustered along functionally diverse street-blocks. It could be argued that plot size is the most valid variable to explain both physical and functional change in Midtown. While, smaller plots are physically more persistent and shows relatively higher resistance to physical change, larger plots tend to be changed physically more often. In terms of functional change and adaptation, small and medium size plots perform better than the larger ones. These preliminary findings should be questioned with the help of different morphological variables and measures at different contexts, and supported with a coherent statistical analysis to draw further conclusions.

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