Extended Abstract (1200-2000 words)

Comprehending the varied spatial polarization between traditional and emerging Indian metropolises

Introduction

Spatial polarization is one of the key concepts in contemporary urban research, which is often associated with the growing gap between geographic locations. It is considered a unique form of vertical inequality with a locational attribute. The spatial polarization phenomenon can be perceived at different spatial scales of development, though its interpretation differs across the scales. At the macro-scale (e.g., metropolitan region), it often indicates a worsening divide between polarizing communities at different geographic locations regarding their economic opportunities, income differences, and developmental gaps. In contrast, at the micro-scale (e.g., neighborhood or city), spatial polarization associates itself with the clustering of population groups from economic extremes in distinct locations of the city, which is a direct manifestation of economic polarization. Economic restructurings in recent decades have contributed to spatially polarized urban landscapes worldwide due to increasing social polarization, wealth accumulation, and developmental activities in specific city parts with simultaneous impoverishment of other parts, making it the biggest concern for urban researchers.

Following the economic reforms, Indian cities are also experiencing spatial polarization where wealthier parts of the cities receive preferential action from the government, increasing amenities and urban renewal efforts. In contrast, the poorer parts of the city continue to decline due to the negligence of policies, government initiatives, and the concomitant rise of informality. The traditional metropolitan cities and the emerging metropolitan cities attended diverse growth patterns during this period. Existing studies often highlight that Indian cities are experiencing socioeconomic polarization. However, no comprehensive research shows how these varied growth dynamics impacted the patterns of spatial polarization responding to their regional and local policies. In order to fill this research gap, this study investigates the pattern of spatial polarization in major Indian metropolitan cities through empirical investigation of both traditional and emerging metropolises. The primary aim of this study is to examine the spatial polarization trend in traditional and emerging metropolitan cities using nighttime light data and to comprehend how these trends relate to city-specific policy reforms after the economic liberalization. The paper attempts to visualize the trends of spatial polarization observed in the selected metropolises in the past few decades and validates them through the existing policy discourses.

The objectives of this study are:

1. To analyze the degree of polarization in the traditional and emerging metropolises since economic liberalization and to identify the pattern of spatial polarization in the cities using Consistent and Corrected Nighttime Light (CCNL) data; and
2. To evaluate the interlinkages of the spatially polarized urban landscapes and assess the impacts of these reforms on inducing spatial polarization on the urban fabric through policy review and document analysis.

Research Methodology

Given the scarcity of temporal data on income, amenities, or other inequality-related data in India, the study adopts an innovative approach to illustrate spatial polarization. It uses Night time light images, specifically the CCNL data, to show how the cities' polarization pattern has evolved over time. The CCNL data has a

coarse resolution of approximately 1 km. X 1 km. However, it has been particularly used in this study because it provides broader temporal data (1992-2013) compared to the high-resolution Visible Infrared Imaging Radiometer Suite (VIIRS) data (2014 onwards). Unlike Defense Meteorological Satellite Program Operational Linescan System (DMSP-OLS) data, it successfully eliminates issues like interannual inconsistencies, blooming and saturation effects which were prevalent in earlier datasets. The pixels of the CCNL data are encoded with digital numbers (DN), which provide information on light intensity that can be considered a proxy for developmental activities. The higher values of the DN correspond to well-developed areas with intense economic activities, extensive residential lighting, better infrastructure, and often the high-income zones of the city, whereas the lower values of the DN correspond to the underdeveloped, impoverished zones, which are predominantly found in lower-income neighborhoods.

The study primarily focuses on the urban contiguous areas while largely excluding the sparsely developed areas/large recreational zones and waterbodies to improve the accuracy of the analysis. The urban extent of the selected cities was extracted from the Google Earth Timeline Imageries for 1992, 1997, 2002, 2007, and 2012. The corresponding CCNL images were extracted from Google Earth Engine Code Editor using Javascript. For the first objective, the study first identified the level of polarization in the selected cities by analyzing their encoded DN values. It then identified the probability distribution curve of the encoded DN values for each city for the selected periods. The area under the curve was then divided into DN_{low}, $DN_{median,}$ and DN_{high}. While DN_{low} corresponds to the area under darker patches or disadvantaged (blighted) areas of the metropolises having DN values much less than the median, DN_{high} corresponds to the highly illuminated or advantaged (elitist) areas with DN values much higher than the median. The DN_{median} represents the in-between areas between these darker and highly illuminated patches, where DN values mostly fall around the median. The polarization index was then calculated by considering a ratio of DN_{median} to [DN_{high} + DN_{low}]. To comprehend spatial polarization, we applied the Anselin Local Moran's I index on the pixel values to identify the high-high (HH) and low-low(LL) clusters of DN values within the urban fabric. Cities were deemed spatially polarizing if the HH and LL clusters had increased in size over the period with a widening gap between their median values. We prepared spatial maps for each city over the selected periods to see how their pattern of spatial polarization has changed over time and how it relates to the polarization index. For the second objective, the study employed relevant policy and document analysis to comprehend how neoliberal policies and their associated spatial implications (both direct and indirect) have contributed to intensifying/ de-intensifying spatial polarization in these cities at an urban agglomeration level.

Analysis and Discussion

The analysis was conducted on two traditional metropolises (i.e., Mumbai and Delhi) and three emerging metropolises (e.g. Hyderabad, Bangalore, and Ahmedabad). According to the polarization index, traditional metropolises are more polarized than emerging ones, but the increase in polarization over the five periods is much more intense in the emerging metropolises. However, the spatial mapping of Moran's I index reveals a different output. Mumbai, Hyderabad, and Ahmedabad tend towards a spatially polarized urban landscape. In contrast, for both Delhi and Bangalore, we can observe a gradual transition of LL clusters to HH clusters with urban expansion and shift of the LL clusters to the urban peripheries, which does not essentially portray spatial polarization at a urban agglomeration level but is more indicative of urban growth, peripheral marginalization and growing gap between core and peripheries. Unlike Delhi, in Bangalore, the LL clusters only expand in the Southern part, which compels us to review its existing urban processes. In all cities, the HH and LL clusters have grown in absolute numbers, and their clustering pattern has become spatially significant over time, questioning the very effect of spatial polarization. The increase/decrease in the median values of the HH and LL clusters over the five periods followed the same pattern, which conforms to the overall economic changes. However, the difference between the median

values of the HH and LL clusters has mostly remained stable in the cities (e.g., Mumbai) or has widened (e.g., Hyderabad), indicating a persisting developmental gap between the clusters that makes us question the city-specific spatial policies.

For the second objective, we identified the city-specific spatial policies that have direct and indirect impacts on channelizing spatial polarization and demonstrated how they conform to the spatially polarized landscape derived from the CCNL analysis. In Mumbai, world-class city initiatives, imposition of transferable development rights (TDR), and lopsided slum redevelopment schemes are the major drivers of city-scale spatial polarization. In Hyderabad, preferential action of government and the formation of knowledge enclaves are the major contributors to the spatially polarized landscape that has divided the city into affluent western and impoverished eastern parts. Contradictorily, Ahmedabad is experiencing a growing spatial divide due to local industrial restructuring that is biased due to place-specific ethnocentricism.

Results and Conclusion

The study provides important lessons about studying spatial polarization in India. First, the study identifies that the degree of economic polarization in major Indian agglomerations is increasing in the post-liberal period. Their translation into a spatially polarized landscape depends on the localized spatial policies specific to each city's pre-existing economic profile and cultural settings. Second, it shows that the spatial polarization in Indian cities at the urban agglomeration level has been majorly induced by the preferential actions of the government (e.g. making of World class city in Mumbai, Cyberabad in Hyderabad, etc.), premature industrial decline (specifically traditional industries like textile) that led to major informality (e.g. Mumbai, Ahmedabad) and removal of informal areas to specific city parts (e.g., Mumbai, Hyderabad. Third, it identifies that in all the cities, the average Local Moran's I index of the HH clusters is more significant than the LL clusters in most selected periods, suggesting that clustering of higher values is more prominent in the Indian cities. Therefore, spatial polarization in Indian cities has been primarily propagated by the concentration of wealthier parts or increasing amenities in specific city areas. Last, the study highlights that how we perceive spatial polarization depends on the scale of our analysis, e.g., the degree of polarization in Delhi is much greater than in Ahmedabad. However, Ahmedabad seems more spatially polarized than Delhi according to the spatial mapping of local Moran's I index. While Delhi may not seem spatially polarized due to its massive size and the scale of analysis, at a neighborhood or ward level, we can trace micro-scale spatial polarization. If we focus at a micro level (i.e., each pixel of the CCNL image), we can observe polarization in terms of spatial juxtaposition of affluent enclaves with that of enclaves of the poor. It justifies the consideration of carefully choosing the scale in the polarization study.

The study makes a novel contribution to global literature by unveiling the dynamics of spatial polarization of both traditional and emerging Indian metropolises, thereby linking them with the post-liberal policy reforms. In a data dearth condition, this study helps to unfold the dynamics of spatial polarization of cities at an urban agglomeration level by incorporating the nighttime light dataset, which can easily be reproducible and has larger temporal data. To the best of our knowledge, this study is the first of its kind to provide comprehensive research on connecting neoliberal policies and the spatial polarization trend of Indian cities.

Keywords: Spatial Polarization, traditional and emerging Indian metropolises, Consistent and Corrected Nighttime Light Data, Policy reforms, city-specific neoliberalism and spatial policies