Analysis of Activity Population and Mobility Impacts of a New Shopping Mall Using Mobile Phone Bigdata

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Abstract. This paper is an explorative research, examining the impact of the new shopping mall, Hyundai, in Seongnam city of Korea. The focuses are on the activity population and mobility around the major shopping malls in the city, including three pre-existing major shopping malls. For this purpose, we analyzed mobile phone records in 2015 and 2016, before and after the new shopping mall. The data represent total mobile users in Korea. The number of activity population in the Hyundai mall increased by 103%. The new shopping mall negatively impacted the nearest shopping mall, AK, decreasing activity population by 3%. Internal and external mobility showed that visitors coming from all regions to the Hyundai mall were increased, while internal population visiting to the SK mall showed mixed results. Local government and urban planners will find this case study to be of interest with regards to mitigating the impacts of a new shopping mall development in similar urban situations.

Keywords: Impact analysis · Shopping mall · Activity population
Mobility

1 Introduction

Shopping malls are one or more buildings from a complex of shops representing merchandisers with interconnecting walkways that enable customers to walk from unit to unit (Wikipedia). Nowadays they are not just for shopping, but are places where consumers visit for doing diverse activities for social life, economic activities, entertainment, recreational, and cultural functions. Shopping malls have become an inseparable element of spatial functions in large cities. In particular, most urban cities in Korea have mixed used developments, and shopping malls offer consumers with an attractive and integrated community in which to live, work and shop.

Shopping malls attract buyers, sellers and customers. They choose a shopping mall based on store assortment, convenience, distance to malls, economic advantage and leisure facilities (Rajagopal 2009). Previous studies of the impacts of shopping malls have focused on the economic impacts (ICSC 2013; McGreevy 2016), the social impact on a city (Heffner and Twardzik 2014), the change of the functional structure of city (Dickinson and Rice 2010), and the choice of shopping malls (Borgers et al. 2013; Rajagopal 2009). It is inevitable that the opening of a new shopping mall has an impact

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on pre-existing shopping malls as well as on activity patterns in the surrounding area of shopping malls.

The purpose of this paper is to examine the impact of a mega shopping mall, Hyundai Pangyo department store in Seongnam city of Korea, on the surrounding business district, and the pre-existing and competitive shopping malls located in the city. The focuses are on the activity population around the major shopping malls in the city, and on the spatial impacts and mobility of the visitors to the area. This study is an explorative research, and attempts to address those issues by examining mobile phone bigdata before and after the opening of the new shopping mall. Although when using mobile phone data it is hard to precisely distinguish shoppers or visitors inside the mall from those outside the mall, an analysis of changes in the number of activity population and mobility can provide valuable information on the planning issues that emerge from such major shopping mall developments.

The paper reviews the study area and the dataset in the next section. It then presents the analysis of activity population and mobility surrounding four major shopping malls in the city. Conclusions and future researches are discussed in the final section.

2 Study Area and Mobile Phone Bigdata

2.1 Study Area

Seongnam is the second largest city in Korea's Gyeonggi Province and the 10th largest city in the country. Its area is 141.72 km^2 and population is about one million. Seongnam is a satellite city located immediately southeast of Seoul, and largely a residential city. Bundang, one of three districts in Seongnam, is a planned city and was developed in the 1990s to accelerate the dispersion of Seoul's population to its suburbs and relieve the congested Seoul metropolitan area. All four major shopping malls analyzed in this paper are located in the Bundang district of Seongnam.

The Hyundai shopping mall has opened in August, 2015. It is a big, complex shopping mall with about 900 shop units, 210 brands, 100 restaurants, and parking space for 2,700 cars. The building has 13 floors above ground and 6 underground. The total floor area is about 233,518 m^2. The lot area is about 22,905 m^2, which is equivalent to two soccer fields. Before the opening of the Hyundai shopping mall, there were big three shopping malls, including AK Plaza, Lotte, and NC, in Bundang-gu. Activity population and mobility of four shopping malls are compared in this paper.

2.2 Description of Mobile Phone Data

As of 2014, about 57 million people owned mobile phones in Korea, which is equal to 1.13 mobile phones per person on average. Thus, most of adults and teenagers have a mobile phone. For this analysis, we used the SKT's mobile phone data. The original mobile phone records were collected and preprocessed by SKT. First, every mobile phone signal is received by a nearby cellular tower, and the existing location and time information is stored in a server. Mobile traffic is identified by phone calls, SMS messages, notifications or updates from apps, or Internet connections. A location of

mobile phone is initially identified by a cellular tower, albeit covering a large area of at least 2,500 m^2. Thus, SKT further segregated the identified location into a square cell area (50 m by 50 m), based on a spatial correlation of land use and the weights of the total floor areas of building types. SKT, one of three mobile phone telecommunication operators in Korea, consistently held about half of the country's total mobile phone memberships. Before providing the dataset, SKT further expanded their mobile phone records to include the total mobile phone users in Korea, using the country's market share rate. This is a huge advantage for the population and mobility analysis because the dataset represents the total population of mobile phone users.

The daily records consist of 16 columns (Table 1). The data include information on the number of users at each cell grouped by age and gender of users, the coordinates of the cell location, and the user's home location. It should be noted that it is a daily-based records, and double counts are not allowed in the same cell in the same day. The data do not store a person logs in order to protect privacy. For this study, we analyzed two weeks of data in two years (March 16–22, 2015 and March 14–20, 2016). The dataset include about 160 million records per day on average.

Table 1. Structure of daily mobile phone data.

Columns	Variable	Description
1	Date	Date of data
2–3	X, Y	Position of the center of a cell based on the UTM-K coordinate system
4–9	Number of men by age groups	Daily mobile phone users (men) by 6 age groups (10s, 20s, 30s, 40s, 50s, over 60s)
10–15	Number of women by age groups	Daily mobile phone users (women) by 6 age groups (10s, 20s, 30s, 40s, 50s, over 60s)
16	Home	Code of home location of users

3 Analysis

3.1 Changes of Activity Population

We analyzed one week of mobile phone data in each year of 2015 and 2016. Activity population is defined as the number of mobile phone users in this paper, who are located in a 50 m cell. To compare activity population before and after the opening of a new shopping mall, we need the number of population visiting to a shopping mall. However, when using mobile phone data, it is very difficult to identify whether people are inside a shopping mall with purposes of vising the mall, because the data does not have an activity or trip purpose and the exact destination. Thus, we extract the number of activity population located within a certain catchment area instead of in a cell. This study specifically interested in the comparison of changes of activity population, including shoppers in the mall as well as visitors around the mall. For this reason, we analyzed activity population in catchment areas ranged from 100 m to 300 m with an interval of 50 m, and we determined 300 m as the reasonable catchment area in this paper.

First, we examined activity patterns by day of the week, and found that they were very similar to all shopping malls. The number of activity population gradually increased from Monday to Friday, and dropped on weekends. The peak activity population was appeared on Friday. However, activity patterns in 2016 showed slightly different patterns in 2015. The number of activity population on Saturday was lower than that of Monday in 2015. However, the number of population on Saturday was very similar that of Monday in 2016. All shopping malls showed these patterns.

We compared average daily activity population in four malls in 2015 and 2016. We compared average daily activity population within 300 m before and after the new shopping mall. Activity population in the Hyundai shopping mall increased by 103% in 2016, while that of the AK shopping mall slightly decreased by 3%. The AK mall is the nearest shopping mall from the Hyundai mall, locating in 1.3 km away from the east-south of the Hyundai mall. Thus, the opening of the Hyundai mall negatively impacted the AK mall. On the other hand, activity population in both Lotte and NC malls increased by 8% and 78%, respectively in 2016. The distances are 1.6 km and 2.4 km, respectively, away from the Hyundai mall. So, it is interesting that the NC mall was not negatively impacted by the Hyundai mall.

We analyzed shows the population differences of three shopping malls in each catchment areas. In all catchment areas, activity population in 2016 in the AK mall were decreased compared to those in 2015, while those in the Hyundai mall were increased. The activity population in the Lotte mall decreased within 250 m, while they are increased within 300 m.

3.2 Changes of Mobility

Shoppers are willing to sacrifice longer distances and travel times in order to go to larger shopping malls with more options. According to the spatial interaction theory, the distance a consumer is willing to travel to a shopping center is proportional to the size of the shopping center even though the shopping center is far (Openshaw 1975; Kanoga et al. 2015). Therefore shoppers spend more on travel cost and time to get what they want from a larger mall as long as it is accessible.

We analyzed visitors to each shopping mall, and particularly focused on the place where they are coming from, using the home location information from mobile phone data. For this purpose, we divided activity population into two groups depending on the home location: (1) internal population, whose home is in Seongnam, and (2) external population whose home is outside of Seongnam, such as Seoul and Gyeonggi. Internal population in all administrative dongs of Seongnam visiting to the Hyundai mall were increased on both weekdays and weekends in 2016. External population were also increased in all outside regions, except Gangwon-do. Compared to the Hyundai mall, internal population visiting to the AK mall showed mixed results: that is, the number of internal population visiting from Seohyun-dong and Backhyun-dong was increased, while the number was decreased visiting from Jungja-dong. External population visiting to the AK mall from most of regions outside Seongnam were decreased.

4 Conclusion

This paper is a preliminary research attempting to assess the impact of the opening of the new shopping mall, using mobile phone data. It compared the new shopping mall and the pre-existing shopping malls, focusing on activity population and mobility surrounding the shopping malls.

First, activity patterns by day of the week were very similar to all shopping malls, gradually increased from Monday to Friday and dropped on weekends. However, the number of activity population on Saturday in 2015 was much lower than on Monday, while its on Saturday in 2016 was very similar on Monday in 2016. Second, we compared activity population within 300 m of each shopping mall, and found that the new shopping mall, Hyundai, negatively impacted to the nearest shopping mall, AK. The number of activity population of the Hyundai mall increased by 103%, while that of the AK shopping mall decreased by 3%. Third, we investigated visitor's mobility. Internal and external population visiting to the Hyundai mall were increased in 2016, compared to 2015, while the population visiting to the AK mall showed mixed results.

It is difficult to separate actual mall visitors from people not actually visiting to the mall when using mobile phone records. Nevertheless, local government and urban planners will find this case study to be of interest with regards to mitigating the impacts of a new shopping mall development in similar urban situations.

More works in the future are expected for the analysis of the impact of a new shopping mall such as identifying the factors affecting activity population around shopping malls and interconnecting the reason for vising shopping malls with land use information and network service.

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