

# Predicting Commercial Land Requirements in New Cities using Big Data Analysis of Expenditure and Traffic Data

Si Yeol Kim<sup>1</sup>, Yong Jin Kim<sup>2</sup>

<sup>1</sup> Principal, Private Development 2 Team, Development Business Division, New Millennium Construction Co., Republic of Korea, [sijosae123@new2001.com](mailto:sijosae123@new2001.com)

<sup>2</sup> Professor, Department of Urban & Transportation Engineering, Korea National University of Transportation, Republic of Korea, [yj-kim@ut.ac.kr](mailto:yj-kim@ut.ac.kr)

Corresponding author: Yong Jin Kim

**Abstract:** In developing new cities in Korea, inaccurate land demand forecasts can cause social problems such as the stagnation of commercial areas and large-scale unsold commercial facilities. In particular, stagnation of commercial areas and large-scale unsold commercial facilities in new cities reduce the attractiveness of the entire commercial area of new cities, causing great damage to the self-employed in the area. In Korea, more than 10 new cities were created from the 1980s to the early 2000s, but the stagnation of commercial space in the new city is considered a problem due to the prediction of demand for commercial land. This study aims to estimate the appropriate purchasing power of new cities based on the actual consumption expenditure and transportation demand of new cities, and to estimate the appropriate gross commercial area. The subjects of the study are five new cities in the Seoul metropolitan area, including Byeonae, Wirye, Misa, Okjeong, and Dasan. This study uses secondary data for analysis, including card usage data and traffic OD data for each new city. As a result of the analysis, the amount of consumption or purchasing power spent in the new cities was estimated to be around KRW 200 billion to KRW 300 billion. Considering the average annual sales per square meter of commercial facilities in Gyeonggi-do, the estimated total commercial area per new city was approximately 50,000 to 70,000 square meters. When compared with the actual total commercial area supplied to each new city, the difference ranged from 3.8 to 5.5 times. These findings have important implications for the oft-cited oversupply of commercial space in new cities and the resulting unsold and frequent closures. The results of this study will provide implications for the planning and supply of appropriate commercial land in subsequent development projects such as the third new city.

**Keywords:** Big Data Analysis, Commercial Land Area Estimation, Consumption Expenditure, New City, OD Analysis

## 1. Introduction

The global liquidity easing policy to prevent a recession due to the COVID-19 pandemic is causing a surge in asset values[1]. In response, the U.S. has aggressively raised interest rates, while South Korea has promoted large-scale housing supply by developing new cities in the third phase to address the problem of rapidly rising housing prices. In developing new cities, the planning and supply of commercial and self-sufficient land in addition to residential land has an important impact on the overall performance of the new city and the subsequent revitalization of the new city[2]. In particular, if there

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is an oversupply of commercial land in the new city, the commercial vacancy rate will be high, which will affect the revitalization of the commercial area, and the number of shops will be high compared to the demand, which will cause a loss of competitiveness and an increase in business closures[3]. This situation leads to the collapse of the economic base of the self-employed in the new city, and at the same time creates a vicious circle that reduces the vitality of the commercial area of the entire new city[4]. In fact, since Bundang, the first new city, the problem of oversupply of commercial land and the resulting large amount of unsold commercial land has been continuously raised[5]. More recently, Sejong, Wirye, and Misa have also experienced high vacancy rates and business closure rates, and in response, the government has supplemented relevant regulations, such as the 2018 Public Housing Business Handling Guidelines, to establish appropriate area and planning standards for the efficient supply of commercial facilities in new cities[2]. However, despite these efforts, Korean cities will still face the same problems if they do not reflect fundamental changes in commercial activities, such as the rise of online shopping.

In particular, during the COVID-19 pandemic, global social distancing restrictions on face-to-face activities have led to a sharp increase in online shopping, and in Korea, online shopping has grown rapidly by about 66% in the three years since the COVID-19 outbreak[6]. This change, in turn, directly affects the increase or decrease in the proportion of offline shopping centers and means that the urban structure itself needs to change. Therefore, it is important to estimate a reasonable commercial area that takes into account the actual consumption patterns of the region in the creation of new cities.

This study aims to estimate more rational new city purchasing power based on consumption expenditure and traffic of actual new city residents and to present a methodology for estimating the appropriate total floor area of commercial facilities. The methodology for estimating commercial land requirements in this study will provide implications for the planning and supply of appropriate commercial land in subsequent development projects such as the third new city.

## 2. Literature Review

### 2.1 Research on Commercial Land Demand Estimation Methods

To provide an adequate amount of commercial land in new cities, various quantitative estimation methods have been used to estimate the appropriate commercial land area[7]. First of all, the regression analysis method is based on the concept that the required area of commercial land is affected by various variables such as economic size, income level. The regression analysis method derives a model by identifying the influence of each variable. The regression analysis method derives a model by identifying the influence of each variable, which can be calculated in the following ways: "forward addition method", which prioritizes the addition of variables with higher relative importance using the partial F test; "backward elimination method", which removes variables deemed less important after all variables are applied; and "stepwise selection method", which derives a model by repeating the addition and removal of variables[8].

Next, there is a method for estimating the area required by the analog method. This is a method that selects a city with a similar population size, area, industrial structure to the city where the required area is estimated, and estimates the required area of commercial land based on the current status of the previously selected similar city. The comparative analogy method has the advantage that it is relatively easy to estimate the cost compared with other cost estimation methods when the characteristics of the city are diverse and there are many factors to consider, but it has the disadvantage that it involves subjective judgment from the stage of selecting similar cities, so the cost estimation results are likely to be derived without objectivity. The comparative analogy method can reduce the likelihood of subjective judgment depending on the researcher's expertise and quantified experience, but it is a limited area estimation method in that it is difficult in practice to exclude all subjective judgments of the researcher,

and the results may vary greatly depending on the researcher[9].

The method of estimating the commercial area requirement based on the population using the commercial area is to estimate the number of people who can use the commercial area based on the resident or planned population of the city, and then multiply the required area per person to obtain the required area. After that, it is a cost estimation method that estimates the commercial land area by applying the planned floor area ratio and public land ratio in the area[9][10].

Estimating the required area by the commercial purchasing power is a method that analyzes the planned population of the city to be developed, the distance to neighboring cities, the transportation convenience, and the living area, and establishes the commercial areas (primary commercial area, secondary commercial area) based on it, and then calculates the commercial purchasing power by the population size and the commercial absorption rate within the commercial area, and divides the calculated purchasing power by the average annual sales per commercial facility area to obtain the required commercial facility area[11]. In addition, the calculated commercial facility area is divided by the appropriate floor area ratio that reflects the conditions and characteristics of the district to obtain the commercial land area[12]. This method is based on the size of the hinterland commercial facility area, but the problem is that there is a large possibility of arbitrariness in the estimation and application of indicators in setting the commercial facility area, estimating the absorption rate of the commercial facility area by product type, and calculating the appropriate floor area ratio, so the estimation results may vary widely depending on the planner.

Recently, a method has been proposed to estimate the required area considering the traffic O/D. Lee et al.(2016) estimated the commercial land area using traffic O/D by purpose, and argued the importance of the commercial land estimation technique using traffic O/D by purpose[13]. However, there are limitations in that the study only used commercial traffic O/D data as an independent variable, and the study was conducted without distinguishing between commercial facilities and zoning districts.

## **2.2 Application of Commercial Land Demand Estimation Method in Korean New Cities**

Looking at the commercial land demand estimation methods of the first phase of new cities in the metropolitan area, Ilsan New City, Bundang New City, Pyeongchon New City, Sanbon New City, and Jungbu New City all have in common that the commercial land demand was estimated based on commercial purchasing power and comparative analogy, but there are some differences in the steps and process of synthesizing each demand estimation method and the detailed method of estimating the required area for each new city.

In the case of Bundang, Ilsan, and Sanbon, the service facility area is simply added by qualitatively judging the ratio of service facility area in similar cases, and the comparative analogy method is used for the purpose of calculating commercial land units per capita. On the other hand, Pyeongchon and the Middle East show a more sophisticated estimation process in that they use a combination of sales facilities calculated by commercial purchasing power and appropriate retail, business and service facility industry ratios calculated by comparative analogy to estimate commercial land. In particular, the case of Pyeongchon can be evaluated as having a more sophisticated estimation process in that it estimates costs by commercial land hierarchy[9].

Looking at the main techniques used to estimate the area required for commercial land in the second new city, there is a similarity with the first new city in that the area required for commercial land was estimated based on commercial purchasing power and comparative analogy. However, in the case of the second phase of new cities, it can be seen that various methods of estimating the required area, such as the method of estimating the required area by population, the area of commercial facilities per worker, the MCI model, the proportion of residential area and the proportion of total area, are used to estimate the demand for commercial land in each new city, which is somewhat advanced in terms of diversifying

the application of estimation methods.

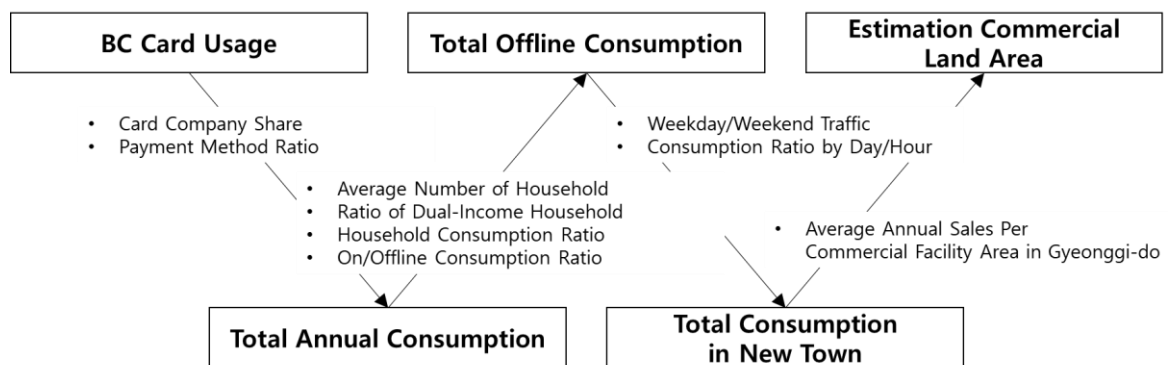
The demand estimation methods and procedures of the second new cities also have various problems. In Kodok New City, estimation methods that lacked objectivity were used to estimate demand, and in Dongtan New City and Pangyo New City, the basis for selecting figures such as raw units, floor area ratio, and floor area ratio used in demand estimation was not clear.

### 3. Research Method

This study used a methodology for estimating the required area based on commercial purchasing power to estimate the reasonable area of commercial facilities in the new city. The method based on the commercial district purchasing power is theoretically very good based on the size of the commercial district of the rear residential area, that is, the size of the purchasing power. In particular, unlike past studies that derived purchasing power based on estimation of income levels in new cities, this study required estimation of purchasing power based on credit card expenditure data by households in new cities.

Next, to exclude the randomness pointed out as a limitation of purchasing power-based commercial district estimation, the method of estimating the required area by traffic volume O/D was used together. Through this, it was possible to more precisely estimate the total usable purchasing power that occurs purely in commercial facilities in new cities among the purchasing power of each household.

To estimate the demand for commercial real estate in new cities, the study utilized actual card usage data and traffic ODs to derive more detailed regional purchasing power, and the estimation process through data analysis is as follows.



[Fig. 1] Research Flow

The main sources utilized in this study are listed in the following table.

Specifically, we collected 60,976 credit card (BC) usage data for one year in 2019 from 10 complexes of 84m<sup>2</sup> condominiums and public rental apartments, the most common types of condominiums, in five second-tier new cities in South Korea. Based on this, we estimated the consumption amount for the entire new city for one year by considering the share of payment amount by card company, card/cash usage ratio (payment method payment ratio), and offline payment amount. Next, we analyzed the proportion of payments by day of the week, proportion of payments by time of day, and OD data to estimate the amount spent within the new city out of the total amount spent in the new city over a year. Considering the average annual sales of commercial facilities in Gyeonggi-do, we analyzed the appropriate commercial gross floor area of the new city. Finally, to verify the appropriateness of the methodology for estimating the appropriate commercial area of new towns, the difference between the estimated appropriate commercial area and the actual commercial area of each new town was compared

with the number of closed stores.

[Table 1] Featured Resources and Sources

No	Data	Sources (Base Year)
1	BC Card Usage Data	Financial Big Data Platform (BC Card, 2019) [14]
2	OD Traffic Volume by Purpose	Gyeonggo-do Traffic Infromation Center (2019) [15]
3	Payment Amount Share by Card	Management Disclosure by Card Company (2019)
4	Payment Method Ratio	Payment Method Survey (Bank of Korea, 2019) [16]
5	Household/Consumer Expenditure Ratio	KOSIS(2019) [17]
6	Offline Payment Ratio	Financial Big Data Platform (BC Card, 2019) [14]
7	Ratio of Payments by Day/Hour	Bank of Korea (2019) [16]
9	Economically Active Population Ratio	KOSIS(2019) [17]
10	Average Annual Sales Per Commercial Facility Area in Gyeonggi-do	KOSIS(2018) [17]
11	Number of Closed Stores	Local Administrative License Data(2019) [18]

## 4. Results

### 4.1 Estimating Offline Consumption Expenditures Per Household

To represent the income and consumption levels of the residents of the new city, an apartment complex with a private area of 84m<sup>2</sup> and a public rental apartment complex were selected. Next, since the data was limited to BC cards, the annual per capita consumption was derived based on the domestic market share of BC cards and the proportion of card payments among payment methods. To estimate the actual purchasing power available for consumption in the new city, various utility bills and housing management fees were excluded based on the household consumption expenditure ratio (0.7282), and online consumption was excluded based on the online-offline payment ratio (0.8028). Finally, the annual local consumption expenditure was estimated based on the average household size of 2.4 people, the number of apartments for sale, and the number of apartments for rent in each new city.

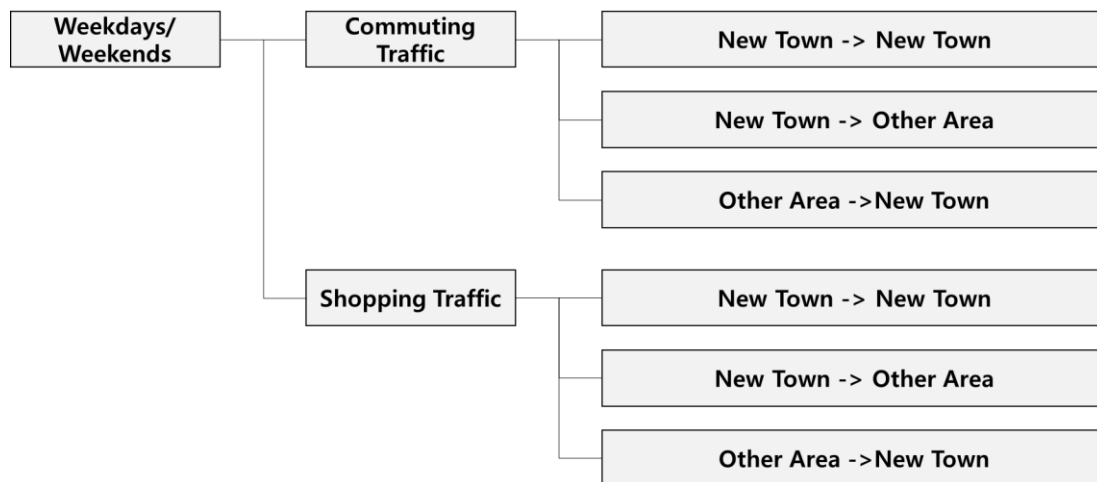
[Table 2] Estimate Annual Consumption per Household of 5 New Cities

	Own/Rent	Estimate Annual BC Card Usage Per Capita (Won)	Estimate Annual Comsumption Per Capita (Won)	Estimate Annual Consumption per Household in New City (Won)
Byeolnae New City	Own	7,126,999	71,885,330	540,070,747,177
	Rent	6,163,636	62,168,525	
Wirye New City	Own	8,681,746	87,567,029	415,978,886,301
	Rent	6,045,714	60,979,124	

Misa New City	Own	7,594,250	76,598,182	557,151,623,369
	Rent	6,101,015	61,536,908	
Okjeong New City	Own	8,785,729	88,615,838	541,134,971,594
	Rent	5,916,940	59,680,259	
Dasan New City	Own	8,971,997	90,494,605	435,411,405,975
	Rent	8,248,174	83,193,878	

In all five new cities analyzed, the consumption expenditure of condominiums is slightly higher than that of rental apartments. In four of the five new cities, except for Dasan, the estimated consumption expenditures for rental apartments were similar. This difference can be explained by the fact that there are differences in the sale price of publicly distributed apartments in different new cities, resulting in differences in income and consumption levels, whereas the estimated consumption expenditure of rental apartments is similar because the income level of residents is common. However, it can be understood that the consumption expenditure in Dasan New City is somewhat higher because it includes the initial cost of moving in, as the first residents started moving in in 2019.

#### 4.2 Estimation of Commercial Land Demand Area Considering Traffic OD



[Fig 2] Traffic by Main Purpose in New Towns on Weekdays and Weekends

Not all of the annual regional consumption expenditures estimated above can be considered to be spent within the new city. To re-estimate the amount spent within the new city, it is necessary to consider the places where people commute to work, go to school, and shop in their daily lives. Therefore, in this study, weekday commuting destinations were categorized based on OD traffic data. However, the ratio of weekday shopping traffic to weekend commuting traffic was not high, so it was excluded from the study.

First, the traffic volume from the new city to the new city, the traffic volume from the new city to other regions, and the traffic volume from other regions to the new city were estimated, focusing on the weekday commuting OD and the weekend shopping OD.

[Table 3] Weekdays /Weekends Traffic by Main Purpose in 5 New Cities

	New City-New City		New City-Other Area		Other Area-New City	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
Byeolnae New City	4,186	8,007	36,871	3,414	12,228	1,497
Wirye New City	5,789	1,406	75,612	16,372	4,792	2,979
Misa New City	160	0	13,836	1,389	9,960	11
Okjeong New City	4,062	0	17,727	467	2,987	0
Dasan New City	3,669	3,177	61,573	5,421	17,668	2,280

The analysis shows that all five new cities have significantly more outbound trips than inbound trips to the new city area. In particular, weekend shopping trips are higher in all new cities except Byeonae. This behavior suggests that the purchasing power in the previous region is unlikely to be translated into consumption expenditures in the new city.

Therefore, by dividing the estimated consumption expenditure per household in the five new cities by mode of transport and taking into account the share of consumption expenditure by day of the week (weekdays: 75.3%, weekends: 24.7%) and the share of consumption expenditure by time of day (9 am to 6 pm (73.5%), after 6 pm (26.5%)), the amount of money expected to be spent in the new cities was calculated. The comparison of annual local consumption expenditure in the five new cities shows that when commuting and shopping are taken into account, the actual amount spent locally drops to 55% in all five new cities. Using the recent average annual sales price of commercial land in Gyeonggi Province(KRW 4.44 million per square meter), where the five new cities in the study are located, the appropriate commercial land demand area based on the purchasing power of each new city was calculated.

[Table 4] Estimates of Purchasing Power and Suitable Commercial Gross Floor Area in 5 New Cities

	Estimated Gross Regional Consumption Expenditures (Won)	Estimated Appropriate Commercial Gross Floor Area (m <sup>2</sup> )
Byeolnae New City	298,940,855,379	67,329
Wirye New City	230,225,594,818	51,853
Misa New City	308,358,351,712	69,450
Okjeong New City	299,493,855,704	67,454
Dasan New City	240,980,619,694	54,275

Finally, it is necessary to determine the appropriateness of the estimation results. To do this, this study analyzed the difference between planned and expected square footage and the number of closed stores in each new city. The difference between the planned commercial land area of the five new cities and the estimated area of suitable commercial land in this study suggests that commercial land has been overplanned and oversupplied relative to the purchasing power of residents in each new city. Furthermore, if the analysis included other types of similar commercial properties that perform a sales function, such as storefront housing, retail in complexes, and service functions in municipal support

facilities, the difference could be expected to be even greater. In the past, commercial area has been estimated in various ways in the planning of new cities, but there is no clear verification method. However, excessive commercial space compared to the effective purchasing power within a new city reduces the competitiveness of individual shopping centers and puts them at risk of closure, and in terms of the new city as a whole, the center loses its vitality. In fact, in the case of Misa City, which had the largest difference between the appropriate commercial area and the actual planned area among the study sites, the number of closed stores reached 523 in the three years to 2019, and in Byeona New City, the number of closed stores reached 1,012 in the same period, indicating a serious problem. However, the difference between the estimated area and the planned area did not show a clear trend in the number of closed shops in the new cities. This result can be attributed to the fact that, in addition to the oversupply of commercial land in new cities, there are various factors that affect business closures, such as the economy and rent, and it is difficult to identify the relationship with the number of new cities, which is limited to five.

[Table 5] Difference from Estimated Appropriate Commercial Gross Floor Area and Closed Stores

	Planned Commercial Gross Floor Area (m <sup>2</sup> )	Difference from Estimated Appropriate Commercial Gross Floor Area (m <sup>2</sup> )	Stores Closed in the Last 3 years (no)
Byeolnae New City	260,000	193,321	1,012
Wirye New City	281,000	229,147	452
Misa New City	384,000	315,035	523
Okjeong New City	284,000	216,546	105
Dasan New City	209,000	154,725	534

Results of the study revealed that the amount of consumption or purchasing power spent in the new cities was estimated to be between KRW 302 billion and KRW 308.3 billion, and a reasonable commercial area was estimated to be between 51,853m<sup>2</sup> and 69,540m<sup>2</sup>. However, the actual delivered commercial gross floor area was significantly different, ranging from 154,725m<sup>2</sup> to 315,035m<sup>2</sup>, indicating oversupply.

Most new cities in Korea are built to provide a large amount of housing, and commercial space is intended to support the residents of the city. Therefore, if an excessive amount of commercial space is built compared to the consumption power of the new city, it will reduce the competitiveness of individual shopping centers and lead to the closure of shopping centers in the new city[19]. In particular, frequent closures and unsold commercial facilities will reduce the attractiveness of the entire city, forming a vicious circle[20]. This problem of oversupply of commercial land in new cities has become one of the major social problems in Korea, and the five new cities in this study have similar problems[21]. In this regard, this study proposes a method to estimate local purchasing power in more detail through card usage big data and transit OD, and confirms the degree of oversupply in the five new cities. The methodology and results presented in this study have important implications for the third phase of new cities.

## 5. Conclusions

This study has significant implications for addressing societal challenges such as the oversupply of commercial space and the resulting problems of unsold space and frequent closures in new cities. It introduces a sophisticated methodology to thoroughly assess the purchasing power within target areas,



taking into account income levels and projected population (number of households). This approach is a valuable reference, especially as new cities enter their third phase of development. More specifically, it is necessary to review the total commercial area area and area ratio based on the commercial land area estimation using the results of this study from the basic planning stage in the future new city construction. In addition, in the supply stage after the creation of the new city, a strategy is needed to supply commercial land step by step at the level of purchasing power through the supply of housing land by applying the results of this study.

Despite these findings, the study has several limitations. First, the study used one apartment complex of 84m<sup>2</sup> each for sale and public rental apartments as representative housing types in the new cities, but this does not include various housing types such as national rental, permanent rental, and single-family houses. Therefore, this study cannot consider the proportion of different housing types in each new city. Second, the study used 2019 data to minimize the impact of COVID-19 on consumption expenditures, but this has the limitation of not fully reflecting the different stages of development of the five new cities studied. In particular, in the case of Dasan New City, the data overlap with the time of move-in, which means that expenditures at the beginning of move-in are included compared to other new cities. Finally, the relationship between the oversupply of commercial land in each new city and the number of store closures was examined, but no significant relationship was found. This is because the limited number of subjects analyzed did not allow for statistical analysis, such as regression analysis, to account for other factors affecting store closures.

In the future, in addition to the method of estimating the area of commercial land, research on detailed demand estimation methods such as business and industrial land will be needed. In addition, according to the characteristics of the new city, studies are needed to classify new cities for housing supply in the metropolitan area, innovative cities for attracting companies in the non-metropolitan area, and enterprise cities.

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