

Article

Basic Analysis of the Correlation between the Accessibility and Utilization Activation of Public Libraries in Seoul: Focusing on Location and Subway Factors

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Abstract: In the past, the utilization rate of public libraries in Seoul could be estimated based on their accessibility. However, several issues emerge if we apply this correlation to the present day. Therefore, we re-examined the causal relationship between accessibility and the utilization rate of public libraries to provide directions for improving the use of public libraries in densely populated cities with growing cultural demand. After investigating the utilization rate of public libraries in Seoul from 2015 to 2019, the degree of utilization activation (DUA) was set as the dependent variable, and the integration of public libraries (derived by the quantification of urban space with space syntax) was set as the independent variable. A hypothesis was established to examine the causal relationship using statistical techniques. According to the results, the derived index values had independence and normality, but the accessibility index of public libraries did not exhibit a causal relationship with DUA. It was verified that the causal relationship recognized in the past (where accessibility was the sole predictor of utilization rate) cannot be applied to public libraries in the present day. Modern factors affecting DUA may involve either user motivation or the recent developments in public libraries compared to the past.



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Keywords: urban hierarchy; accessibility control; utilization rate; public library; space syntax; Seoul

1. Introduction

1.1. Background

In July 2021, the United Nations Conference on Trade and Development (UNCTAD) upgraded South Korea's status to "developed country" [1]. Since its founding, the UNCTAD has never upgraded a member state's status from "developing country" to "developed" [2]. Economic factors are the standard criteria for assessing a country's development level [3,4]. However, in major cities in Europe, the US, and Japan, the promotion of cultural infrastructure [5,6] with the purpose of improving the quality of life of their residents [7,8] is also significant [9,10]. On the one hand, museums and art galleries (among other cultural infrastructures) not only promote domestic culture but also convey a nation's knowledge to the outside world [11,12] through exhibits [13,14]. On the other hand, libraries focus on providing users with cultural knowledge, social education, and free access to information [15–17]. Typically, exhibits are presented in foreign languages to promote museum and art gallery exhibitions [13,18,19]. In contrast, most public libraries in countries with specific language cultures provide literature information services in their native languages, even if it is necessary or more appropriate to use foreign languages [17,20–22]. This phenomenon explains why museums and art galleries focus on drawing foreign visitors, which is, of course, in accordance with their intended use. It, likewise, infers that public libraries are usually oriented toward their native populations. In addition, people visit museums or art galleries less frequently, and for shorter periods of time, than public libraries [20,23].

This, in turn, demonstrates the potential for public libraries to boost their usage, since they provide a wider variety of information sources compared to exhibitions, which usually have specific themes.

In the late 1990s, public libraries in Korea shifted toward user-centered systems as the demand for cultural activities increased [24–26]. Policies and practices to establish and reorganize public libraries have already been initiated in Seoul [27]. In accordance with the increased trend toward improving and developing new cultural infrastructures, the Seoul Institute’s City Urban Research Information Center revealed, in 2016, that the rate of opening new public libraries in Seoul had increased by 104.5% from 2007 to 2015, representing the highest introduction rate for new cultural infrastructure in Seoul [28]. This trend indirectly shows that people’s demand for public libraries has continued to increase, even after the 2000s. In particular, the government’s comprehensive plan to initiate information services for libraries since the 2000s has promoted the development of user-centered public libraries [29]. Since then, communication spaces, such as open-complex cultural spaces, have maintained their previous functions as informational, educational, and cultural resources while providing new cultural experiences to users. Moreover, the number of community centers serving as community hubs and makerspaces has increased [29–31]. Therefore, while still serving their original purposes, public libraries in Korea are consistently evolving into places where individuals may gather in comfort. However, despite the fact that the number of public libraries in Seoul has rapidly increased since 2015 to meet citizen demands [28,29], most of the newly established libraries are located in geographical locations that are difficult for residents to access, an issue that negatively affects their respective usage [32–34]. Some scholars even thought that the marginalization of public libraries in urban spaces might be the cause of their reduced daily usage [27,34,35]. Based on these claims, many previous scholars in Korea regarded the urban accessibility of public libraries in Seoul as a factor affecting their degree of utilization activation (DUA). In other words, DUA can be considered to correspond to the accessibility of the location of public libraries. In addition, physical accessibility can be affected by various aspects, such as travel distance, transportation means, and lead time [36]. Therefore, the use of efficient transportation means can be an important step toward reducing the time required to reach libraries located at greater distances [37]. Therefore, accessibility-related factors must be considered when investigating the accessibility of public libraries. However, some researchers have stated that changes in user motivation induced by functional changes in public libraries may also affect users’ DUA [38–40], as the trend toward research in Korean public libraries has recently shifted toward integrating space and designing functions and services to provide information to users [41–44]. Consequently, although a causal relationship between accessibility and utilization of public libraries has been previously established, it is now necessary to re-examine this relationship due to changes in DUA caused by functional changes in public libraries and social factors.

1.2. Research Gap, Purpose, and Novelty

Since 2020, research on public libraries has focused on their operation, the provision of non-face-to-face services, and the role of digital technologies in the context of social emergencies [45–47]. This proved to be particularly important during the recent COVID-19 outbreak because it enabled the optimal operation of public libraries through non-face-to-face services and other alternatives. Prior to the COVID-19 pandemic, most studies focused on specific social issues. Since then, international research trends have begun to emphasize public libraries’ provision and popularization of information services as well as their user satisfaction, spatial storytelling, complexation, and placement [48–50]. Similarly, Korean-based research studies have been focusing on public libraries from around 2015 [51–53]. This trend shows that most of the research conducted by Korean and foreign scholars has focused on the development of public libraries compared to the previous years. In contrast, most studies on public libraries related to urban spaces in Korea have excluded remote library locations, as opposed to administrative districts, central regions, and easy-to-access

areas [54–56], and, hence, the importance of transportation factors and the entire urban space is usually not included.

However, a recent study by Zhao evaluated the absolute change in the utilization rate of public libraries and found that this rate was higher in the outskirts of Seoul compared to the average utilization rate of public libraries in Seoul [25]. Although Zhao's study did not explicitly mention the causal relationship between the utilization rate of public libraries and location factors, many preceding studies have interpreted the decline in accessibility in urban outskirts as a hierarchical relationship of urban structure [57–61]. Although the causal relationship between the accessibility of public libraries and their DUA was already established in the past [32–35], Zhao's findings suggest that this causal relationship may not be valid in the present context. As this situation obscures the relationship between the geographic location of public libraries and their usage, it is necessary to review whether accessibility can still be used to estimate utilization rates and improve the usage of public libraries. Further, various studies have been conducted on the urban spatial structure of Seoul around 2010 [62–64]; however, the introduction of new urban plans dictates that we need to update the urban hierarchy of Seoul accordingly.

Therefore, this study investigated the urban hierarchy of Seoul, reviewed the development, distribution, and usage of public libraries, and re-examined the causal relationship between accessibility and utilization of public libraries with respect to the present day. Consequently, our findings aimed to present novel directions to improve the usage of public libraries in densely populated cities characterized by rapidly growing cultural demand, and provide baseline data for establishing and opening new public libraries in the future.

1.3. Range and Hypothesis

According to Article 2-1 of the Libraries Act of Korea [65], public libraries are classified into governmental public libraries founded by the state or a local government and nongovernmental public libraries established by private organizations, and both fall under the category of cultural infrastructure intended to be used freely by citizens. In addition, they are classified into general public libraries, small libraries, libraries for the disabled, hospital libraries, barrack libraries, prison libraries, and children's libraries, according to their characteristics. However, in this study, the libraries for the disabled, hospital libraries, barrack libraries, prison libraries, and children's libraries are excluded because they have specific purposes and user groups. Generally, this study only focused on general public libraries and small libraries, which are likely accessible to the general public, and analyzed their location accessibility, accessibility considering control factors, and DUA. The DUA of public libraries is based on the number of visitors for five consecutive years (from 2015 to 2019 in this study). Consequently, libraries opened after 2016 were also excluded from the scope of this study because the DUA can only be calculated when the same public library operates continuously year after year and because the number of visitors to public libraries has significantly decreased since 2020 as a result of the COVID-19 pandemic [66].

The causal relationship investigated in this study is a concept that has been widely used and mentioned in the field of philosophy [67,68]. More specifically, causal relationships are generally divided into temporal heterochronous (heterochronous causality) and spatial synchronic (synchronic causality) causal relationships [69–71]. Among them, the synchronic causality presented in philosophy has stimulated numerous debates and issues in the academic community due to the development of the quantum entanglement theory in physics [72,73]. However, this study raises hypotheses and validates them by applying heterochronous causality instead of synchronic causality. As mentioned in Section 1.1, the first reason is that this study considers academic arguments on the inevitable causal relationship in which the accessibility of public libraries in Seoul (cause) affects the DUA (result) [27,34,35] and the fact that the causal relationship of events exists in a temporal order. Second, the interpretation of causal relationships in David Hume's ontology is viewed as a process of inferring other beings from an individual being. In addition, human movements are not determined by reason but, instead, by customs and habits [67,70,71].

Consequently, these reasons can be applied to the present study to confirm this causal relationship by referring to the relationship between DUA and the accessibility of public libraries in Seoul in the past. However, according to Hume [71], the changes in usage caused by social factors and functional changes in public libraries correspond to the changes in human customs and habits. Hence, it is necessary to review whether a causal relationship is established due to past causes in anticipation of the changed results.

Therefore, this study sets the accessibility factor of public libraries as an independent variable, corresponding to the “cause,” to verify the causal relationship between accessibility and usage. In contrast, the DUA of public libraries in Seoul is set as a dependent variable corresponding to the “result.” Since this study attempts to verify this causal relationship in the present, the null and alternative hypotheses below were put forward by assuming that past causal relationships could also be applied in the present day. The logical process for verifying causality is shown in Figure 1.

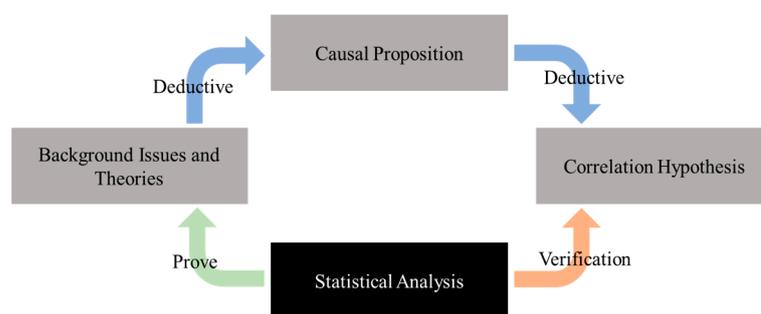


Figure 1. The process of validating causality.

The null hypothesis: The accessibility of public libraries in Seoul affects the DUA and establishes a causal relationship between accessibility and usage.

Alternative hypothesis: The accessibility of public libraries in Seoul does not affect the DUA and does not establish a causal relationship between accessibility and usage.

In addition to the location accessibility of public libraries mentioned above, the controlling factors of accessibility are also essential and must be considered. Thus, in this study, accessibility was divided into the urban accessibility of public libraries and the accessibility of public libraries considering controlling factors, and both cases were examined.

2. Space Syntax and Research Method

2.1. Space Syntax

Hillier and Hanson collaboratively created a set of methods for investigating spatial arrangements (known as space syntax) [74]. According to Figure 2 [75], a space is usually analyzed using convex spaces and axial maps in space syntax. Correlation studies were conducted to evaluate spatial usage patterns and spatial accessibility by calculating their integration with spatial depths as fundamental units [76–78], which have been proven to have significant relevance to social, cultural, economic, and political phenomena in cities [79–84]. Among them, a convex space is a closed polygon in which all interior angles are less than 180° , and an axial map reproduces a space with lines connecting the visual maximum points of the connected spaces [85]. However, when the interior angle of a convex space exceeds 180° or when a refracted space must be expressed with an axial map, the space is typically divided into two or more corresponding spaces [75]. In addition, spatial depth should not be perceived as the actual distance but instead as the proportionate number of spaces necessary to go from one location to another. Based on these rules, Equation (1) shows how to calculate the integration between a convex space and an axial map [74], and Table 1 summarizes the meaning of each symbol [25].

$$I_{(i)} = \frac{D_n}{\frac{2}{n-2} \left(\frac{\sum_{k=1}^n d(i,k)}{n-1} - 1 \right)} \quad (1)$$

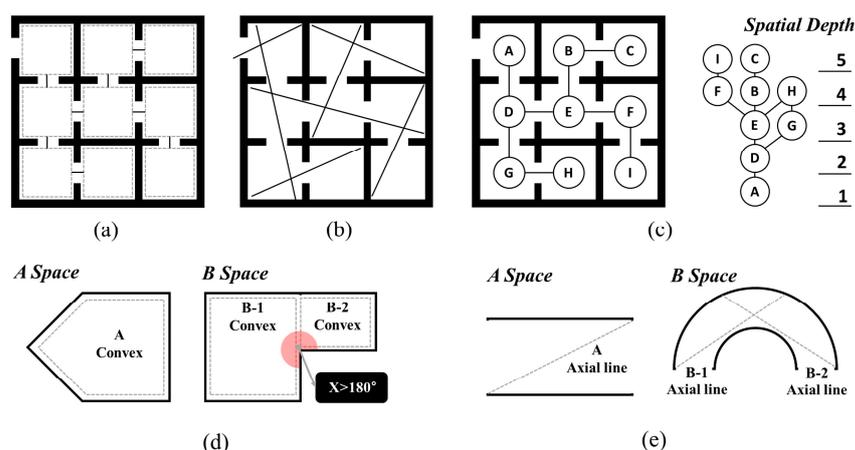


Figure 2. An example of a spatial analysis form: (a) convex space; (b) axial map; (c) J-Graph; (d) creating a convex space; (e) creating an axial map.

Table 1. The interpretation of space–syntax expressions.

Type	Interpretation
MD	Average spatial depth
TSDi	Total spatial depth in space i
S	The number of steps taken through space i
m	The number of steps from space i to the deepest space
K	The total number of spaces
Ks	The number of spaces in Step S
Dn	Correction factor
d(i, k)	The depth from space i to space k
n	The total number of nodes

Space syntax is used to create an urban hierarchy integration index based on axis maps and, thus, investigate the location accessibility of public libraries in Seoul. In terms of the accessibility of public libraries, which is the controlling factor, the present study assumes subway stations as a single convex space, subway stations were connected according to the subway lines, and the distance within 2000 m of each station was set as one spatial depth. The integration was calculated using a topological structure formed by connecting a subway station to the public libraries within a 2000 m radius from the origin. This depth was selected due to the following reasons: First, public libraries have a relatively low probability of being located adjacent to subway stations, as most of them are distant from residential areas [32–34]. Second, according to a 2012 press release by the Ministry of Land, Transport, and Maritime Affairs [86], a relatively low rate of people use transportation to travel within a distance of 2000 m in the city of Seoul, which corresponds to a walking distance for most Koreans. Accordingly, Figure 3 demonstrates an example of an axis map and a convex space of Seoul.

2.2. Research Method

The assessment of the country’s cultural infrastructure released by the Ministry of Culture, Sports, and Tourism [87] in 2021, served as a foundation for compiling fundamental data on public libraries in Seoul. The status of operating general public libraries and small libraries from 2015 to 2019 was investigated by analyzing data from the national library statistics system [88]. Among them, the public libraries that opened after 2015 but were then closed, or did not provide a record of the number of visitors, were excluded from the study. Since this study calculated DUA based on the number of visitors for five consecutive years, there are deviations with regards to the quantification of the data obtained. In addition, this study started with the premise of reflecting both the location accessibility of public

libraries and the accessibility considering the control factors. Therefore, public libraries outside a 2000 m radius from each subway station and those distributed in blind spots were excluded from this study.

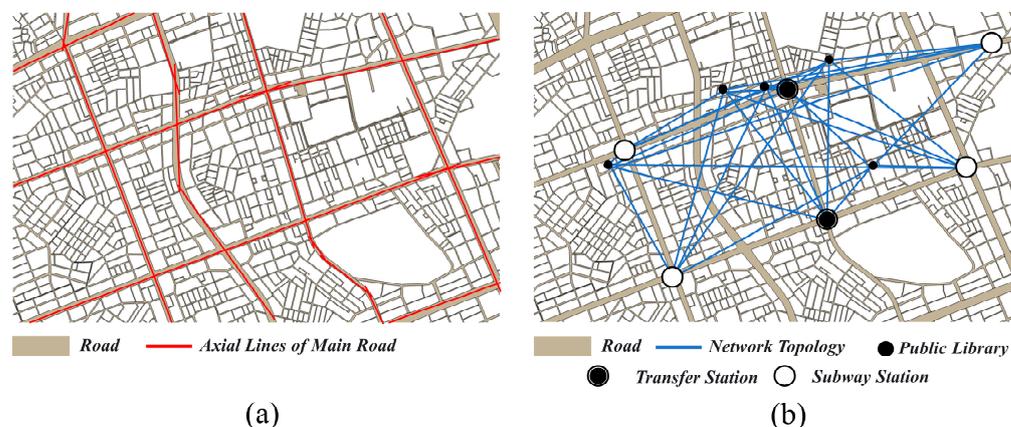


Figure 3. Example of creating an axial map and convex space in an area of Gangnam-gu, Seoul: (a) the axial lines represent major roads; (b) a convex space topological structure of public libraries around a subway station within a 2000 m radius.

According to the above process, there was a total of 1099 public libraries (195 general public libraries and 904 small libraries) in Seoul as of 2021. Among them, 783 were relevant to the scope of this study. Those excluded comprised 296 libraries that closed, stopped operating, or did not have any records on the number of their visitors for five consecutive years. Twenty libraries located in blind spots outside the areas covered by subway lines were also excluded. Information on the subway stations comprising convex spaces was collected on the basis of public data from the Seoul Subway Operation Status Statistics [89]. Based on the Seoul Subway Lines 1 to 9, namely the Gyeongui–Jungang, Gyeongchun, Airport Railroad Express, Bundang, and Ui-Sinseol Lines, 218 general stations and 67 transfer stations were connected to 783 public libraries to create a topological structure consisting of 1068 convex spaces. The National Spatial Information Portal’s GIS public data on the status of ground roads, issued in October 2022, were used as basic data for the Seoul city axial map to examine the accessibility of public library locations [90]. The current state of the roads in Seoul was derived as a DXF file using QGIS and then adjusted to a scale of 1:1 based on a metric system in Auto CAD to arrange a total of 167,292 axial lines. Figure 4 shows the final axial map and the topological structure connecting the convex spaces. Based on the above, the integration of public libraries derived using a space syntax was an independent variable in this study.

In cases where the period for measuring the DUA of public libraries was short, an absolute method was used by expressing the rate of change in the number of visitors to public libraries with the previous year. However, as this study measured the DUA based on the number of visitors for five consecutive years, a relative method was instead used by assuming the starting year as 100% and reviewing the number of visitors for the next four years compared with the starting year to calculate the average value [25]. Therefore, as shown in Equation (2), the final DUA was calculated on the basis of the number of visitors N . Assuming that the value of 2015 was 1, the sum of each ratio, namely N_{2016}/N_{2015} , N_{2017}/N_{2015} , N_{2018}/N_{2015} , and N_{2019}/N_{2015} , was determined by dividing with the total measurement period of five years to obtain DUA, and the closer this value was to 1, the more stable the retention rate was. A value less than 1 indicated the degree of inactivation, and a value greater than 1 indicated the degree of activation. Using the above process, DUA was set as a dependent variable corresponding to the result in this study.

$$DUA = \frac{1 + \sum (i = N_{2016}, N_{2019}) \frac{N_i}{N_{2015}}}{n} \quad (2)$$

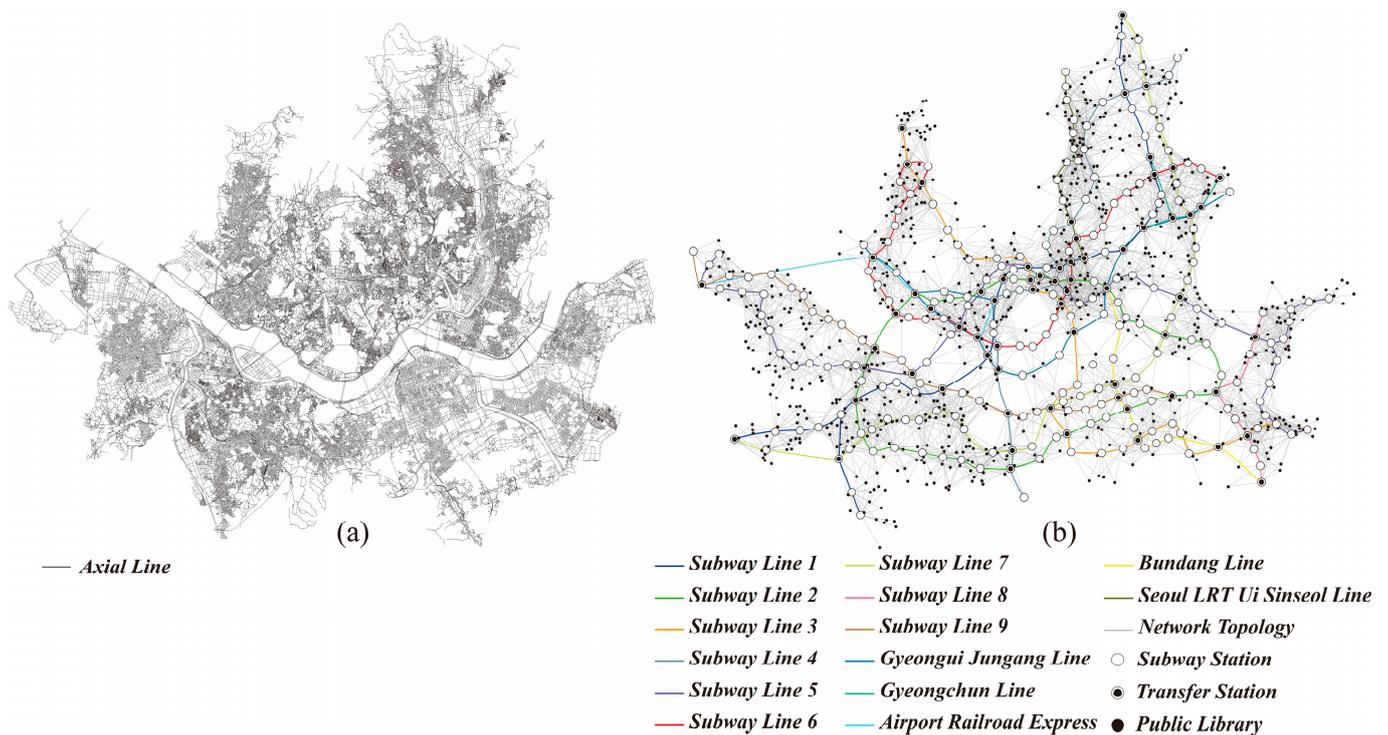


Figure 4. Spatial analysis for calculating public library accessibility indicators: (a) an axial map of Seoul; (b) a convex space topological connection structure of public libraries along the subway lines.

The location accessibility of public libraries, accessibility considering the control factors, and DUA were calculated using the above-mentioned procedure. This study used statistical techniques to verify the normality and independence of data, confirmed the correlation between the independent and dependent variables, and applied regression analysis to determine the influence of the respective causal relationships. However, a linear or nonlinear correlation between the independent and dependent variables could not be obtained from the correlation analysis; the null hypothesis was rejected, and the alternative hypothesis was adopted. The reason was that the premise of conducting regression analysis to statistically confirm causality must be preceded by a correlation. In addition, to compare the index values derived in this study on the same scale, the index values derived using Equation (3) [55] were organized in descending order and converted into relative values within a range of 1.000–0.000. Table 2 demonstrates how to interpret each symbol in the equation, and Figure 5 shows the overall research procedure. In addition, Depthmap, which was developed by UCL, was used to derive the integration indicators using space syntax, and a multiple regression analysis was conducted using IBM SPSS Statistics 25.

$$A_{(r)} = 1 - \frac{N_x - N_{min}}{N_{max} - N_{min}} \quad (3)$$

Table 2. The relative value calculation formula interpretation.

Type	Interpretation
A(r)	The relative interval value of the absolute value
N	The number
N _x	The absolute sequence number of the corresponding
N _x	N _{min} ≤ N _x ≤ N _{max}
Min	The minimum value of the sequence number
Max	The maximum value of the sequence number

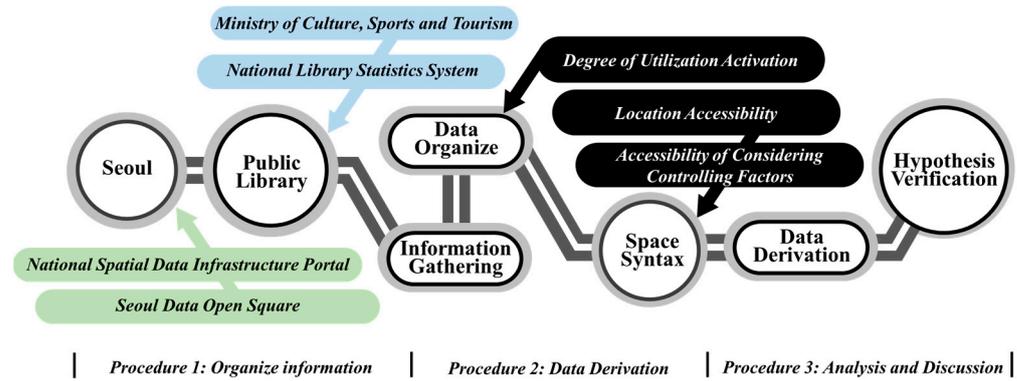


Figure 5. Research process.

3. Analysis and Discussion

3.1. Distribution and Topological Status of Public Libraries in Seoul

Pertaining to the distribution of 783 public libraries by administrative district, Figure 6 shows that Eunpyeong-gu had the greatest number of public libraries, followed by Songpa-gu, Guro-gu, and Gangseo-gu. In contrast, Jung-gu had the lowest number of public libraries. Although a growth in the number of public libraries was far from visible until the 1990s, this number has since rapidly increased due to the greater demand for cultural activities, as previously mentioned. Furthermore, the increasing number of public libraries was a phenomenon that practically defined the framework to meet this cultural demand. In addition, general public libraries accounted for the majority of public libraries that opened before the 1990s, while the number of small libraries was very low. However, when examining all public libraries, 59.6% were public, 40.4% were private, depending on the founding body, 15.4% were general public libraries, and 84.6% were small libraries. This trend highlights that government agencies were the main entities operating public libraries until the 1990s. However, since the 1990s, an increasing number of libraries have been jointly operated by the government and the private sector. In addition, this development trend also demonstrated a clear shift in the administrative pattern of libraries from general public libraries to small libraries. Considering these aspects, including the rapid increase in the supply of public libraries since the 1990s and their functional changes, the dispersed distribution of public libraries in Seoul is notable, with a concurrent large-scale spread of small libraries, as opposed to an intentional absolute concentration.

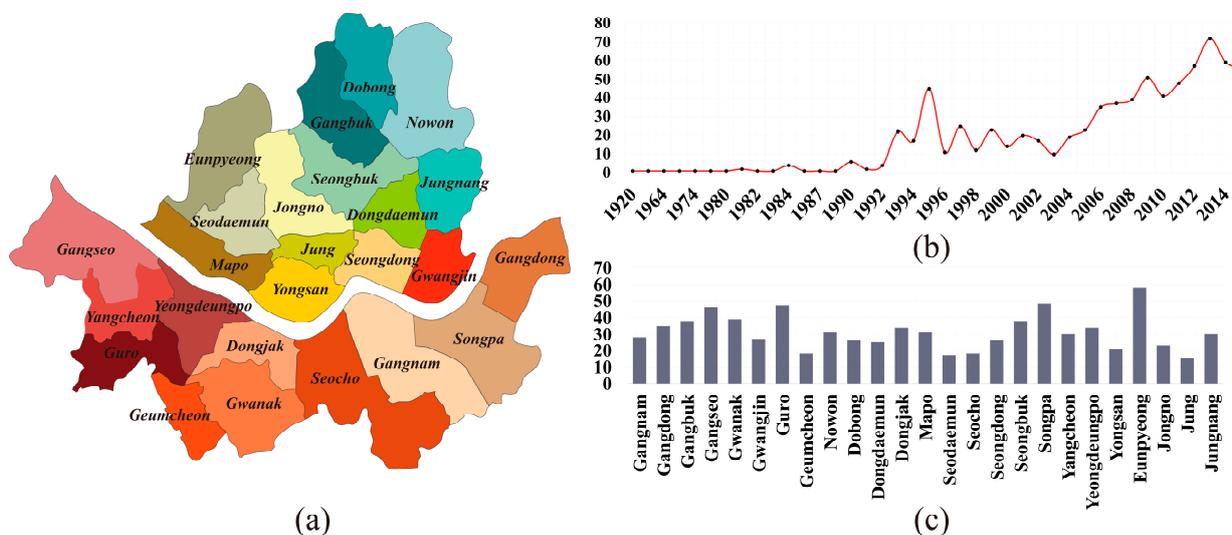


Figure 6. The current status of public libraries in Seoul: (a) administrative districts in Seoul; (b) trends in public library growth by year; (c) distribution of public libraries by administrative district.

According to Table 3, the maximum, minimum, and average values of the location integration of public libraries in Seoul were 0.569, 0.057, and 0.382, respectively. In terms of the integration of public libraries considering control factors, the maximum, minimum, and average values were 1.494, 0.661, and 1.030, respectively, and the average value of the index expressing DUA was 1.279. Since DUA was close to 1, the total degree of using public libraries in Seoul corresponded to a level of maintaining the utilization rate. However, the significant gap between the maximum (16.124) and minimum (0.290) values indirectly showed the potential of large disparities in DUA among public libraries.

Table 3. Urban hierarchy actuality in Seoul.

Type	Integration		Degree of Utilization Activation
	Location Accessibility	Accessibility Considering Control Factors	
Axial line/Convex space/Total library	167,292	1068	783
Max	0.569	1.494	16.124
Min	0.057	0.661	0.290
Avg	0.382	1.030	1.279

Figure 7 exhibits the integration of public libraries in Seoul by describing the location accessibility of public libraries and accessibility considering the control factors. In terms of the location, the administrative districts of Gangnam-gu, Seocho-gu, Gwangjin-gu, Seongdong-gu, and Dongdaemun-gu revealed a relatively high integration. In contrast, Jung-gu and Jongno-gu districts showed the highest accessibility of public libraries according to the control factors. These results may help explain how control factors affect location accessibility. Figure 8 shows a 3D scatter plot created by converting the location integration of public libraries, integration according to the control factors, and DUA into relative values. In that graph, most public libraries with a relative DUA above 0.6 corresponded to small libraries, and small private libraries were concentrated between 0.8 and 1.0.

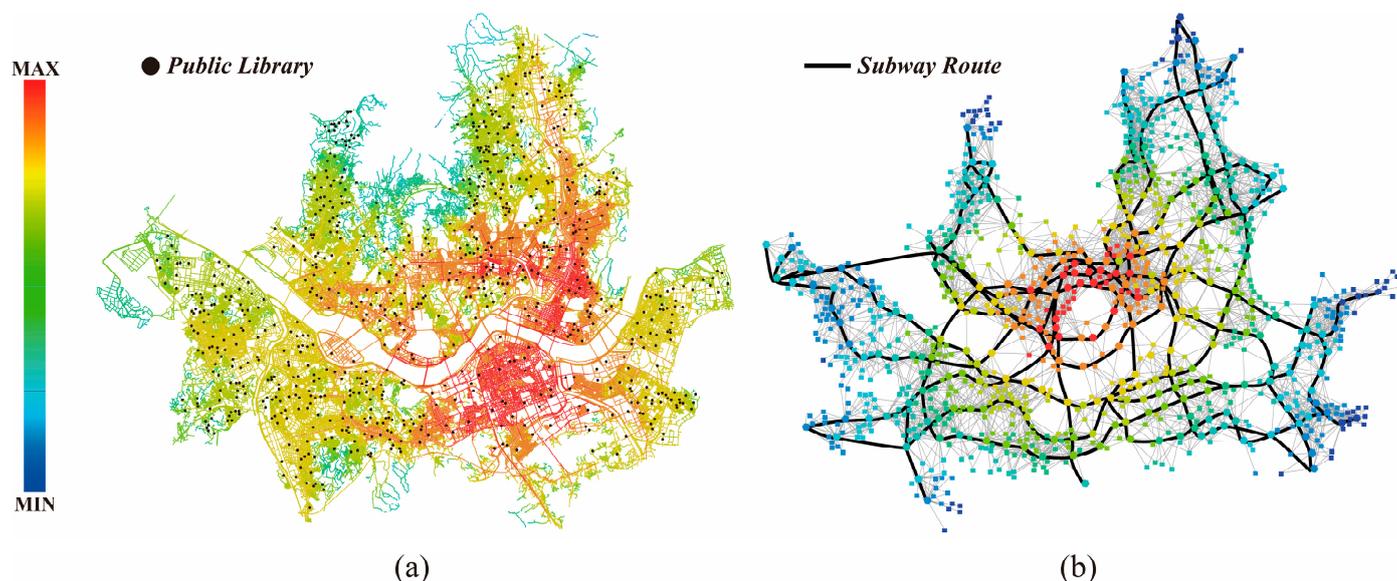


Figure 7. The integration of public libraries in Seoul: (a) axial map integration graph; (b) convex space integration graph.

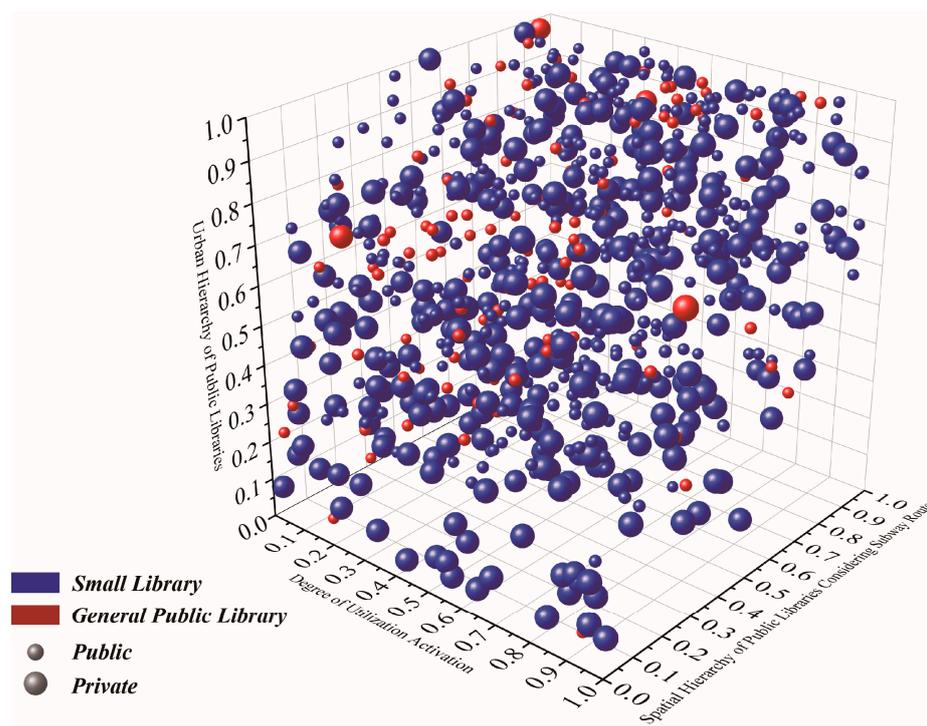


Figure 8. A 3D scatter plot created by the location integration of public libraries, integration according to control factors, and DUA.

3.2. Correlation Analysis of Factors

Prior to validating the correlation of our data, it is necessary to verify the normality and independence of these relative values. Therefore, the normal data distribution was firstly examined using a P-P plot.

According to Figure 9, the location accessibility of public libraries, accessibility considering the control factors, and DUA-converted relative values all fell within a range close to the diagonal of the normal P-P plot. The residuals were distributed above and below the $Y = 0$ baseline in a ± 0.06 range. Therefore, our data followed a normal distribution. Based on this, the Friedman test was conducted on the derived relative values to determine the independence of the overall distribution of the three indicator variables. As previously mentioned, attributes of sequential data were included when converting absolute values into relative values so as to organize these data in descending order. Table 4 shows the results of the analysis. The chi-square value of the location accessibility of public libraries, accessibility considering the control factors, and DUA was 136.350, corresponding to a significance level of $p < 0.001$. Therefore, there is a clear difference in the overall distribution of the three variables.

Table 4. Descriptive statistics.

Kinds	N	Mean	Std. Deviation	Min	Max	25th	Percentiles 50th (Median)	75th	Mean Rank	Chi-Square	Sig.
Location Accessibility ***	783	0.620	0.247	0.036	0.999	0.431	0.652	0.819	2.33	136.350	0.000
Accessibility Considering Control Factors ***		0.470	0.286	0.002	0.999	0.219	0.469	0.706	1.78		
DUA ***		0.500	0.289	0.001	0.998	0.249	0.500	0.750	1.89		

*** $p < 0.001$.

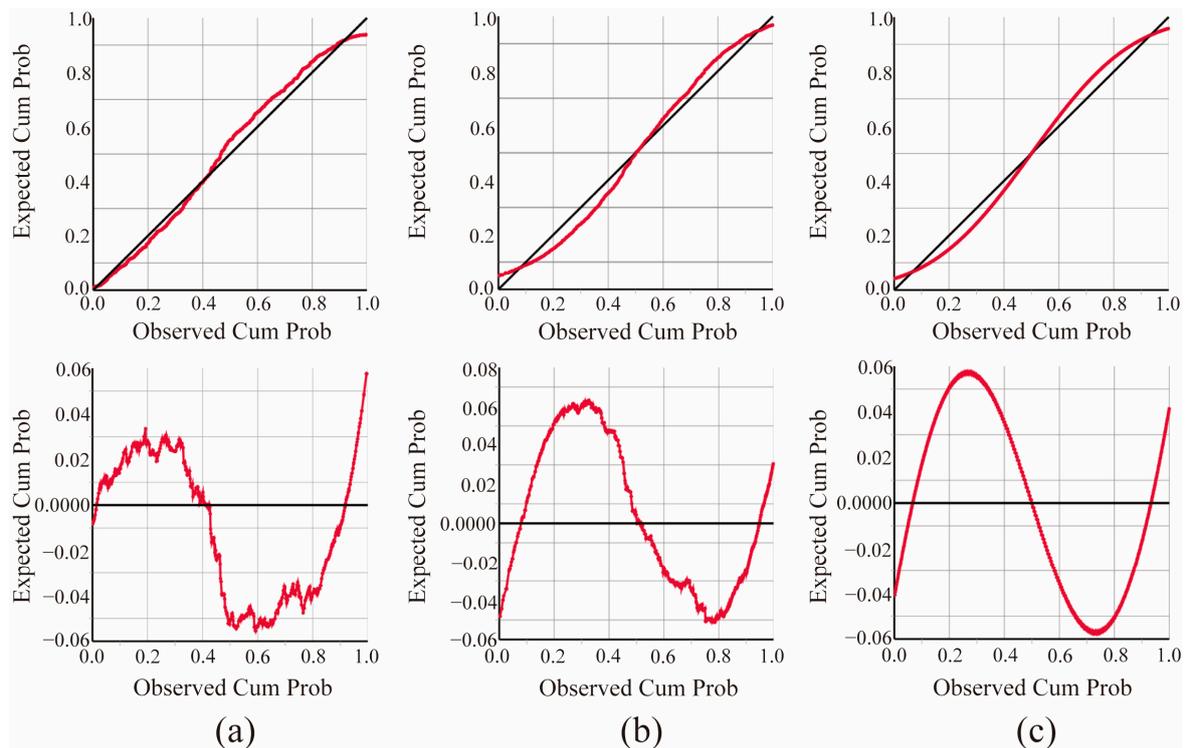


Figure 9. Normal and detrended normal P–P plot: (a) urban hierarchy of public libraries; (b) spatial hierarchy of public libraries considering the subway routes; and (c) degree of utilization activation.

Consequently, a correlation analysis was conducted between the location accessibility, accessibility considering the controlling factors, and the DUA of public libraries in Seoul. However, the correlation between the variables may appear in either linear or nonlinear distributions. Therefore, the correlation analysis was conducted separately using the Pearson correlation coefficient and Spearman's rho correlation coefficient, respectively.

As shown in Table 5, the Pearson's r correlation coefficient was 0.469 between the location accessibility and accessibility considering the control factors and 0.028 between the location accessibility and DUA, and the significance levels were $p < 0.01$ and $p > 0.05$, respectively. The Pearson's r correlation coefficient between the accessibility considering the controlling factors and DUA was -0.002 , and the significance level was $p > 0.05$. Considering these results, the location accessibility and accessibility considering the controlling factors (independent variables) may be connected through a linear relationship. However, there was no linear relationship found between the independent and dependent variables.

Table 5. The linear correlation.

Correlations		Location Accessibility	Accessibility Considering Control Factors	DUA
Location Accessibility	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	783		
Accessibility Considering Control Factors	Pearson Correlation	0.469 **	1	
	Sig. (2-tailed)	0.001		
	N	783	783	
DUA	Pearson Correlation	0.028	-0.002	1
	Sig. (2-tailed)	0.433	0.945	
	N	0783	783	783

** Correlation is significant at the 0.01 level (2-tailed).

Table 6 shows the results of reviewing the nonlinear correlation using Spearman's rho correlation coefficient. In general, the Spearman's rho correlation coefficients between the independent variables (location accessibility and accessibility considering the control factors) and the dependent variable (DUA) were 0.025 and -0.002 , respectively, and the significance level was $p > 0.05$. The Spearman's rho correlation coefficient between the location accessibility and accessibility considering the controlling factors was 0.468 and the significance level was $p < 0.01$.

Table 6. Nonlinear correlation.

Correlations		Location Accessibility	Accessibility Considering Control Factors	DUA	
Spearman's rho	Location Accessibility	Correlation Coefficient	1		
		Sig. (2-tailed)			
		N	783		
	Accessibility Considering Control Factors	Correlation Coefficient	0.468 **	1	
		Sig. (2-tailed)	0.001		
		N	783	783	
	DUA	Correlation Coefficient	0.025	-0.003	1
		Sig. (2-tailed)	0.490	0.930	
	N	783	783	783	

** Correlation was significant at the 0.01 level (two-tailed).

By performing the correlation analysis using Pearson's r and Spearman's rho correlation coefficients, the location accessibility and the accessibility considering controlling factors (the independent variables) were likely to demonstrate linear or nonlinear distributions and appeared significant in terms of correlation. However, according to the research design, the accessibility considering controlling factors is a result calculated based on location accessibility. In other words, although the independence and normality of the data could be confirmed by a normal P-P plot, the research design corresponded to the two cases of expressing accessibility using the same space syntax theory. Therefore, the independent variable was considered to be the cause of internal correlation in the correlation analysis. In addition, the accessibility of public libraries (the independent variable) in both cases did not correlate with the DUA (the dependent variable), in either linear or nonlinear distributions. Therefore, the null hypothesis proposed in this study was rejected, and the alternative hypothesis was adopted instead.

3.3. Discussion

Our findings revealed that the DUA of public libraries did not correspond to the results obtained from interpreting the location accessibility of public libraries and accessibility considering the control factors. These results proved that there is inadequate evidence for estimating DUA based on the accessibility of public libraries in the present day in Seoul and indirectly explained why the utilization of public libraries in the outskirts of Seoul was higher than the average utilization rate published in Zhao's study. Furthermore, the present study demonstrated that the accessibility of public libraries in Seoul was not a major factor for affecting DUA. Although these findings do not exclude a causal relationship in terms of estimating DUA based on accessibility, as indicated previously, they do confirm that the demand for public libraries is determined by changes in customs and habits, in accordance with David Hume's theory of causation. In addition, it becomes evident that it is extremely difficult to apply causal relationships established in the past directly to the present time. Accordingly, it is possible that the main reason people use public libraries is their personal will to obtain knowledge, regardless of whether physical access is easy or not. In other words, the determinants of public library DUA today are highly likely to be influenced by internal factors, such as user motivation, public library service, and space.

4. Conclusions

This study investigated the development, distribution, and utilization rate of public libraries in Seoul to review whether we could still apply the previously established causal relationship between the accessibility of public libraries and DUA to the present time. The location accessibility of public libraries, accessibility considering subway control factors, and DUA were calculated, and research hypotheses were raised. The results of the study can be summarized as follows.

First, the number of public libraries in Seoul has significantly increased since the 1990s. Until the 1990s, relatively large general public libraries were predominant. Since then, the government and the private sector have collaborated to initiate the rapid growth of small libraries in Seoul. In addition, small private libraries accounted for most of the public libraries with a high DUA. Public libraries in Seoul corresponded to a level of maintaining the utilization rate on average; however, there were large discrepancies in DUA among public libraries.

Second, consideration of the subway control factors revealed a distinct difference in physical accessibility between the location accessibility of public libraries in Seoul and the hierarchical center of accessibility, confirming that the addition of additional controlling factors, such as subway routes, can significantly affect the hierarchical accessibility of public libraries. In addition, the location accessibility of public libraries and accessibility considering subway control factors appeared to have independent topological structures, although correlating with each other.

Third, the recent accessibility of public libraries in Seoul did not have a causal relationship with the DUA. The results of the correlation analysis based on linear and nonlinear distributions showed that the independent variable corresponding to the accessibility of public libraries set in this study did not correlate with the DUA. It should be mentioned that these results do not contradict the causal relationship claimed by previous researchers. However, it can be suggested that the reason for interpreting the usage rate according to the development of public libraries may have shifted from the accessibility of public libraries to the users' motivation or the public libraries themselves.

The results of this study are significant in that they present directions for improving the use of public libraries in densely populated cities with growing cultural demand and provide baseline data for establishing and opening new public libraries. However, the present study has certain limitations. For instance, we did not consider the combined use of private transportation, buses, highways, and public transportation when investigating accessibility considering the control factors; therefore, further research needs to be conducted to supplement the results of the present study by including other transportation means. In addition, it is necessary to shift the focus of this research to the users of public libraries or the space itself to understand the factors that directly affect DUA.

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