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# Spatial Analysis of Bank's ATMs in Korea

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# 은행 자동화기기(CD/ATM기)의 공간 분포에 관한 연구

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**Abstract** : Based on a case study of bank's Automatic Teller Machines (ATMs) in Korea, this paper attempts to reveal dynamic changes occurring across the financial landscape with special emphasis on distribution pattern and location factors. Since the distribution of ATMs showed a concentrated pattern similar to that of bank branches, location quotients were examined to consider the effect of branches on ATM distribution. Furthermore, this study identified four factors that play pivotal roles in the location of ATMs. Compared to branch, location of ATM was more closely related to the population and demand factor, while the importance of local economy base and local economic power factor was reduced to some degree. This difference is attributable to the peculiar characteristic of the services offered by ATM. Lastly, demand factor turned out to be most influential in determining the ratio of ATMs to branches in each district, since lower deployment and operation costs allow ATMs to be more flexibly placed where demand for cash services is high.

Key Words : ATM, bank branch, spatial distribution, location quotient, location factor

**요약** : 본 연구는 은행 자동화기기(CD/ATM기)의 공간적 분포와 입지요인 분석을 통해 금융정보화 시대의 역동적인 공간 변화의 한 면모를 밝히고자 하였다. 자동화기기의 공간적 분포는 은행 점포와 비슷한 양상을 보였으므로, 입지계수 분석을 통해 두 분포의 상대적 차이를 밝혔다. 또한, 본 연구에서는 자동화기기의 입지에 중요한 영향을 끼치는 네 가지 요인을 규명하였다. 은행 점포의 입지에는 자동화기기에 비해 지역 경제기반 및 지역경제력 요인의 영향이 상대적으로 중요한데 반해, 자동화기기의 입지에는 인구나 수요유발 요인의 영향이 상대적으로 크게 작용하였다. 이러한 차이는 자동화기기와 은행 점포에서 제공되는 서비스가 차별적이라는 데 기인한다. 한편, 지역별로 점포와 자동화기기의 상대적 분포 차이를 가져오는 데 가장 큰 영향을 미치는 요인은 수요유발 요인으로 나타났다. 이는 점포에 비해 자동화기기의 설치 및 운영비용이 현저히 낮아 현금 수요가 빈번한 곳에 유동적으로 설치될 수 있기 때문이다.

주요어 : 자동화기기, 은행 점포, 공간 분포, 입지계수, 입지요인

## 1. Introduction

Unprecedented developments in information and communication technology (ICT) in recent decades have had dramatic effects on every aspect of our lives, particularly on the financial sector where considerable numbers of transactions occur only with the transmission of information (Park, 2003). The adoption of ICT in the financial sector has not only increased operational speed and efficiency, but also transformed the way in which financial services are delivered. This shift is highlighted by the diversification of financial service channels that transcend time-space limitations, ranging from Automatic Teller Machines (ATMs), telebanking to PC and Internet banking.

Over the last 20 years, these alternative service channels, along with the diminishing role of bank

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branches, have gradually transformed the financial landscape. Now, banking no longer focuses on bringing the customers to bank, but on bringing the bank to customers, essentially changing the bank's strategy from 'bricks and mortar' to 'bricks and clicks.' In this regard, the financial landscape of the digital economy can be fully understood only by incorporating alternative service channels into the traditional branch network.

This paper focuses on analyzing the transformation of financial landscape spurred by advances in ICT based on a case study of automatic teller machines (ATMs) in Korea. In terms of transaction volume and turnover, ATM is the most widely used service channel in the current stage of electronic banking, incorporating both characteristics of offline and online service channels. Based on the assumption that geographical perspectives are still useful in the restructuring of financial landscape with the adoption of ICT, the primary aim of this paper is to explore the spatial characteristics of ATMs, with special emphasis on distribution pattern and location factors.

## 2. Implications of growing ICT Use on the Financial Landscape

A considerable amount of in-depth literature on the financial services sector has accumulated during the past several decades, mostly focusing on bank branches. However, studies incorporating technological changes in banking and financial activities have not yet proliferated. To build a theoretical base for this study, the following two sections briefly describe the geographical implications of the rapid use of ICT in terms of two contrasting issues: increasing financial concentration and financial exclusion.

### 1) Increased Financial Concentration

Various studies of the impact of ICT on the financial sector reveal that the overall extent of financial concentration has been maintained or even increased over time, despite the decentralizing effects of technology. The underlying force of the intensification of financial concentration can be explained from two perspectives.

First, as financial products diversify and transactions involving these products become more sophisticated, the instantaneous availability and exchange of information assume a greater significance. The type of information required in this process is usually embodied in individuals, and thus most efficiently transmitted through locally embedded networks based on mutual trust. Despite the proliferation of electronic systems for the interpretation and manipulation of information, much of the useful information can only be obtained through trust built on face-to-face contact, which is facilitated by spatial proximity (Thrift, 1994; Agnes, 2000). Clark & O'Connor's (1995) study on the informational content of financial products can also be understood as an extension of this concept. According to their typology, the design and execution of 'opaque' financial products are premised on private information, or transaction-specific information, so that the probable market for such products is local, where special expertise can be applied just in time. These studies suggest that geography still matters in finance, which will result in sustained or enhanced comparative advantage of existing financial centers with extensive local presence.

In addition to the emphasis on the role of information on financial activities, the concept of 'path dependence,' introduced by recent studies in the field of 'new economic geography' and especially exemplified in the works of Krugman (1991 a, 1991 b and 1995), provides an insightful tool in explaining the increasing financial concentration in the digital economy. Since the financial sector is characterized by increasing returns to local distribution stemming from location-specific externalities in markets for skilled labor and specialized information, path dependence tends to reinforce the agglomeration force. Due to path dependence, financial institutions are more likely to locate where efficient information flow has occurred in the past in order to preserve this flow in the future as well (Lee & Schmidt, 1993; Thrift, 1994; Porteous, 1999). In extension to this logic, Porteous (1999) points out that path dependence is likely to result in a locational 'stickiness' which would slow the redistribution of financial power between regional centers.

### 2) Financial Exclusion

Studies on financial exclusion are relatively young yet provide useful insight into the changes occurring in the financial landscape. The primary tenet of financial exclusion is the inability of some customer segments to access necessary financial services in an appropriate form due to low or unstable income, demographic characteristics such as age or ethnicity, or geographical remoteness. It can take various forms such as access exclusion, price exclusion, or marketing exclusion (Panigyrakis et al, 2002). Most of the research analyzing financial exclusion focuses on bank branch closures which occur disproportionately in lower income areas and areas with large minority populations (Leyshon & Thrift, 1995; Dymski & Veitch, 1996; Pollard, 1996; Argent & Rolley, 2000).

However, the impact of ICT development on financial exclusion has not been examined from the geographical perspective until recently. In theory, it can be argued that alternative technology-based approaches will reduce financial exclusion to some degree by being able to serve areas that formerly had limited financial access. However, relevant studies point out difficulties in the application of technology-based methods to overcome financial exclusion in terms of financial infrastructure and financial literacy.

In regard to financial infrastructure, Leyshon & Thrift (1994) claim that strategic value of ATM location is no less emphasized than that of bank branches. This results in a tendency to avoid placing ATMs in areas with low expected profitability or high crime rates where branch closures are most likely to be prevalent. Furthermore, some studies emphasize that varying levels of understanding toward technology-based banking methods among customers, known as 'financial literacy', can also have a significant effect on the shaping of financial infrastructure. As shown in a case study of ATM usage on a remote Greek island, views toward ATM usage contrast sharply between users with experience of living in technologically developed areas and those without (Rugimbana, 1995; Panigyrakis, Theodoridis & Veloutsou, 2002). Social and spatial division of financial knowledge as such can be exacerbated by uneven access to information on financial systems or products (Leyshon, Thrift & Pratt, 1998).

## 3. Data and Methods

Due to short operating history of ATMs and difficulty of tracking volatile changes involved in their installation, reliable data is not readily available. The only published source is the Financial Institution Directory issued by The Korea Federation of Banks, but the scale of the data is insufficient for adequate analysis. Thus, data was collected directly from executives in the electronic banking divisions of thirteen banks from the months of June through September, 2003. These thirteen banks include five commercial banks, six local banks, and two special banks which together comprise 70.6% of all bank branches and 73.1% of the overall ATM network[1].

ATMs can be classified into two categories depending on where the machine is placed. The first category is in-branch ATMs which are installed inside or at the outer wall of bank branches. The other category is out-of-branch ATMs which are established off the bank properties, in locations such as universities, shopping centers, or bus terminals. Since over 70% of ATMs are installed inside the branches, it is quite possible that the overall distribution of ATMs overlaps that of branches. Thus, to reveal the different spatial patterns of branches and ATMs, ATMs in this study only refer to out-of-branch ATMs.

For this analysis, spatial distribution of ATMs in Korea is first described and compared with that of bank branches. Then, the location factors of ATMs are examined by regression analysis in comparison with bank branches. Lastly, factors attributable to the regional differences in combination of ATMs and branches are revealed through discriminant analysis. The geographical scope of this research is nationwide and the unit of analysis is the district level, namely Si-Gun-Gu.

## 4. Geographic Characteristics of ATM Distribution

### 1) Spatial Distribution of ATMs

By the end of year 2002, thirteen banks used in this study operated 7,395 ATMs. The number of machines in each district ranges from 0 to 170. As can be seen in Table 1, over half the machines is concentrated in the Capital region, especially in Seoul where the overall share is 30.1%. In other areas, concentration is significant in five metropolitan cities as well as typical Korean industrial cities such as Pohang, Gumi, Changwon, Masan, and Cheongju (Figure 1). However, 43 districts are identified not to have even one ATM by the end of year 2002, which comprises 18.5% of the total region. The average population of the districts without ATMs is less than 100,000, which indicates that these districts tend to be relatively small in size and remote in location. Such contrast in the distribution pattern reveals that the distribution of ATMs is closely related to demographic factors.

### 2) Comparison of Distribution Patterns between ATMs and Branches

This section examines the distribution of ATMs by taking into account the location of branches. While

Table 1. Regional distribution of ATMs, 2002

| Region | ATMs | |
|---|---|---|
| | Number | % |
| Seoul | 2,229 | 30.1 |
| Busan | 672 | 9.1 |
| Daegu | 417 | 5.6 |
| Incheon | 316 | 4.3 |
| Gwangju | 264 | 3.6 |
| Daejeon | 205 | 2.8 |
| Ulsan | 183 | 2.5 |
| Gyeonggi | 1,285 | 17.4 |
| Gangwon | 168 | 2.3 |
| Chungbuk | 256 | 3.5 |
| Chungnam | 197 | 2.6 |
| Jeonbuk | 190 | 2.6 |
| Jeonnam | 164 | 3.1 |
| Gyeongbuk | 470 | 6.4 |
| Gyeongnam | 287 | 3.9 |
| Jeju | 95 | 1.3 |
| Total | 7,395 | 100 |

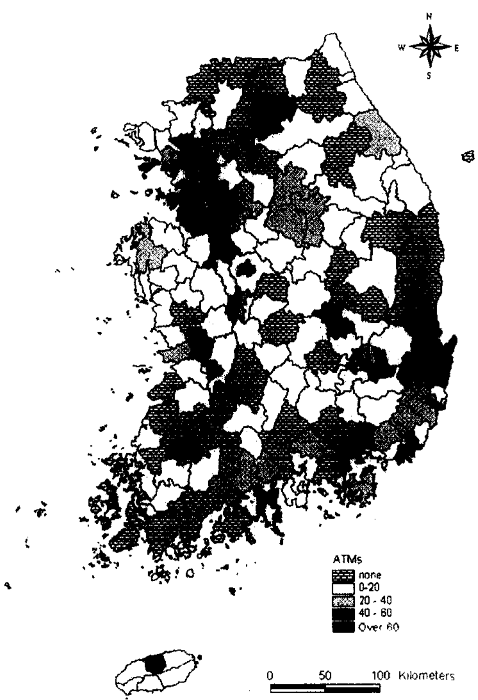


Figure 1. Regional distribution of ATMs, 2002

the former section is necessary for understanding the overall pattern of ATMs, evaluating the presence of ATMs in the context of branch network is also relevant in highlighting important findings. With only the analysis of the former section, difficulties arise in interpreting whether ATM distribution reflects either the number of branches in a region or the specific characteristics of the region. To allow for the fact that each machine is managed by the adjacent branch rather than operated independently, a variation of location quotient will be adopted in the analysis. Applying the concept of location quotient, the ratio is defined as follows (Equation 1):

Equation 1:

$$LQ = \frac{Ai/A}{Bi/B}$$

$A_i$: number of ATMs represented by district $i$

$A$: number of ATMs nationwide

$B_i$: number of bank branches represented by district $i$

$B$: number of bank branches nationwide

where the numerator indicates the proportion of number of ATMs represented by district $i$ and the denominator indicates that of bank branches represented by district $i$. In general, a location quotient of one signifies that the district has its fair share of the ATMs. In this analysis, instead of adopting a strict interpretation of the location quotient, a location quotient of 0.8 to 1.2, one standard deviation from one, is regarded as such. Thus, location quotient of less than 0.8 implies that the district has a relatively small share of ATMs compared to branches while location quotient of more than 1.2 suggests that the district is relatively over-presented in terms of ATMs.

The location quotient of each district is shown in figure 2 and 3. The regional variations of location quotient show stark differences between the Capital region and the provinces. In the Capital region, one of the major characteristics revealed in the distribution pattern is the predominance of location quotients under 0.8. This pattern is especially prominent in the districts which rank in the top five in terms of number of bank branches, namely Gangnam-gu,

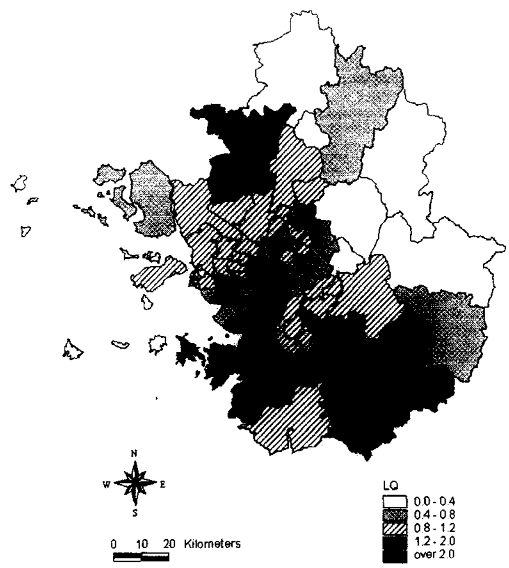


Figure 2. Location quotients of the Capital region

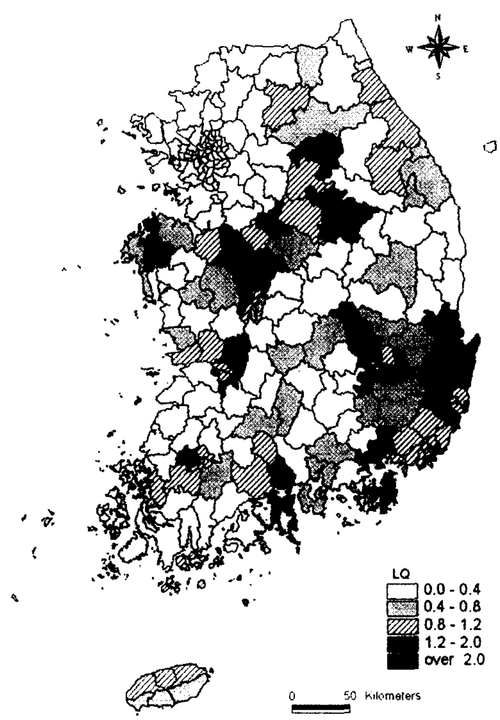


Figure 3. Location quotients of the provinces

Seocho-gu, Jung-gu, Jongno-gu, Yeongdungpo-gu. On the other hand, districts with location quotients over 1.2, in general, have number of bank branches less than the average. This pattern indicates that the distribution of ATMs is relatively decentralized compared to the bank branches, thus contributing to reduce the concentration of financial infrastructure to some degree. Since ATMs act as a financial services access point, though limited in its service range, it can substitute for the presence of a branch where establishing one might be inefficient (Lee, 2004). In Incheon and Gyeonggi, there is a marked contrast between the north and south, where location quotients under 0.8 prevail in the northern area excluding Paju-si, while location quotients over 1.2 are prevalent in the southern area. The rapid growth of population and commercial facilities over recent decades is one of the main reasons for the high demand for financial services reflected by these ratios.

In the provinces, number of districts with location quotients under 0.4 increases significantly, especially in the districts that have less than 10 branches. This indicates that regions with smaller branch networks are more likely to be excluded from the benefits of technological development in banking and face what might be called a dual financial exclusion. Among districts that have less than 10 bank branches, however, nine districts are identified with location quotients over 1.2. The predominance of ATMs relative to branches is technically possible, since ATMs can be managed not only by branches in the same districts, but also by those in adjacent districts (Lee, 2004). In the districts that have more than 20 branches, location quotients under 0.8 decrease to a significant degree, suggesting that ATM infrastructure is more likely to concentrate where bank branch network is already densely developed. This contrasting pattern of location quotients between the under-branched districts and over-branched districts suggests the possibility that alternative service channels which are thought to overcome geographical constraints might widen, rather than narrow, the pre-existing gap in financial infrastructure.

## 5. Analysis on Location Factor

### 1) Selection of Variables

Based on literature reviews on the location of financial institutions and interviews with bank executives, eleven factors attributable to the location of ATMs were identified. These include total establishment, total worker, producer service, producer service worker, population, population density, ratio of population over age 65, large store (department store, shopping center), university, and local tax burden per capita. The district level data on these variables were obtained from the statistical yearbook published by the Korea National Statistical Office.

The first four variables were taken to represent an essential aspect of financial services as one of a producer service. As implied by the definition of the term, producer services tend to serve intermediate demand for other establishments rather than final demand for general consumers. Thus, studies on the location of financial institutions emphasize the importance of establishments in the region, particularly the producer services which comprise the foremost part of financial demand (Esparaza & Krmenec, 1994). In this regard, these four variables are expected to have a positive relationship with the number of ATMs.

Population, population density, and ratio of population over age 65 were selected to reflect the demographic characteristics of ATM users. These variables are considered to have significant importance to the location of ATMs, since financial services provided by ATMs, in general, are targeted for final demand. Thus, demographic profiles are expected to be more closely associated with the location of ATMs than that of branches. The ratio of population over age 65 was also selected to reflect the varying perceptions toward ATM usage according to age group.

Large store and university variables were chosen to represent facilities that create demand for financial services. These are places where large flows of people are concentrated and demand for financial services arises as a result. Local tax burden per capita was included to reveal the association between the location of ATMs and the region's economic base. Lastly, total length of paved road was included based on the premise that accessibility of a region may influence the location of ATMs. These four variables are also expected to be positively correlated to the number of ATMs in the district.

The estimated correlation coefficients of ten variables are statistically significant at 0.01 level (Table 2). As expected, all the variables except the ratio of population over age 65 are positively correlated with the location of ATMs and branches. The ratio of population over 65 is more negatively associated with ATMs than branches, since the use of ATMs is contingent on the ownership of a credit card. Since the overall demand for financial services as well as the rate of using cash cards is relatively low among those over 65, the result is a stronger negative correlation with ATMs than with branches.

Table 2. Comparison of correlation coefficients between ATM and bank branch

| Variable | ATM | Bank branch |
|---|---|---|
| Total establishment | 0.853* | 0.863* |
| Total worker | 0.859* | 0.934* |
| Producer service | 0.789* | 0.954* |
| Producer service worker | 0.689* | 0.918* |
| Population | 0.789* | 0.645* |
| Population density | 0.585* | 0.566* |
| Ratio of population over age 65 | -0.607* | -0.498* |
| Large store | 0.695* | 0.650* |
| University | 0.502* | 0.293* |
| Total length of pavement | 0.087 | -0.021 |
| Local tax burden per capita | 0.261* | 0.349* |

*: Significant at $\alpha$=0.01 (two-tailed), Sample size = 233

As the Table 2 illustrates, some differences can be found between the correlation coefficients of ATMs and branches. While the variable that has the highest correlation with ATM is total worker, it is the producer service for bank branches. Also, branches have higher correlation than ATMs for all the variables related to establishments. On the other hand, ATMs are more associated with other variables such as population, population density, large store, and university. Explanation for these differences will be examined in the context of partial correlation coefficients of multiple regression analysis in the next section.

Based on the result of correlation analysis, the next step is to investigate the relative importance of each variable in determining the location of ATMs and compare them with those of branches. However, a careful examination of the correlation matrix indicated multicollinearity among the independent variables which makes the result of regression analysis problematic. For example, correlation coefficients among the establishment related variables, establishment and population were higher than 0.8. Thus, factor analysis was used to reduce the amount of data and determine the nature of basic dimensions of the data matrix. To convert the variables into orthogonal factor dimensions, principal-components method with varimax rotation was used. The minimum eigenvalue for the retention of a factor was one.

The factor analysis identified four dimensions which account for 88.94% of the original variance (Table 3). After examining the loading of each variable, general labels were assigned to the individual factors. Factor 1 included establishment related variables and accounted for 36.7% of the total variance, summarizing the variables that represent *local economy base*. Factor 2, labeled *population*, recorded positive loadings for population and population density, accounting for an additional 23.4% of the total variance. Factor 3 was comprised of large store and university variable which described *demand* creating facilities for financial services. Factor 4, describing

Table 3. Results of factor analysis

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|---|---|---|---|---|
| Total establishment | 0.693 | | | |
| Total worker | 0.852 | | | |
| Producer services | 0.899 | | | |
| Producer services worker | 0.949 | | | |
| Population | | 0.729 | | |
| Population density | | 0.908 | | |
| Ratio of population over age 65 | | | | |
| Large store | | | 0.608 | |
| University | | | 0.929 | |
| Local tax burden per capita | | | | 0.965 |
| Eigenvalue | 3.673 | 2.341 | 1.802 | 1.077 |
| Accumulated variance explained | 36.727 | 60.141 | 78.164 | 88.937 |
| Factor Label | Local economy base | Population | Demand | Local economic power |

Note: Only factor loadings over 0.6 were presented.

*local economic power*, contributes to 10.7% of the explained variance and primarily indicates the economic power of residents.

## 2) Analysis of Location Factor

In this section, location factors of ATMs are revealed and compared to those of bank branches based on the regression analysis results using factor scores as independent variables. In deciding the input and output of variables stepwise method was used.

The estimated regression coefficients of the model were highly significant at 0.01 level for both ATMs and bank branches (Table 4). The R-square for the models were considerably high, at 0.818 for ATMs and 0.941 for branches. All the coefficients were positive, in line with what would be expected. This implies that the higher the level of local economic base, population, demand, and local economic power, the higher the number of ATMs or branches. The relative size differences of the regression coefficients between ATMs and branches need to be examined in detail.

The regression model of ATMs reveals that the local economy base is the most crucial factor in determining the location of ATMs. However, the importance of the local economy base factor is relatively low compared to that of branches. This is attributable to the fact that essential services offered by branches include lending and investment, which are directly related to the economic base of a region. Therefore, the location of branches becomes sensitive to the potential demand for banking services, which in turn is driven by the local economy. On the other hand, services provided by ATMs are mainly cash withdrawal, deposit, or transfer, on which local economic base has less direct impact. Also related to this is the impact of local economic power factor. While it is the least influential factor in determining the number of ATMs, in the case of bank branches it becomes more important than demand factor. Differences in regression coefficients of population and demand factor can be understood in extension to this logic as well. Both coefficients are larger for ATMs than branches, which suggest the importance of population flows and facilities in creating demand for ATM services. Furthermore, the relative ease of establishing and managing ATMs gives priority over bank branches when there are constraints in building branches. For example, building a branch

Table 4. Results of regression model

| | Variable | Unstandardized Coefficient | Standardized Coefficient | t-value |
|---|---|---|---|---|
| ATM | Local economy base | 0.661 | 0.632 | 22.353* |
| | Population | 0.515 | 0.512 | 17.398* |
| | Demand | 0.420 | 0.401 | 14.190* |
| | Local economic power | 0.130 | 0.124 | 4.391* |
| Bank branch | Local economy base | 0.884 | 0.854 | 53.265* |
| | Population | 0.425 | 0.410 | 25.598* |
| | Demand | 0.128 | 0.123 | 7.701* |
| | Local economic power | 0.174 | 0.168 | 10.501* |

*: significant at $\alpha = 0.01$ (two-tailed); Sample Size = 233

in every university or shopping center would be unprofitable even though there might be a large amount of demand for cash services. In such cases, it becomes far more efficient to open an ATM than a branch, therefore leading to different spatial patterns for ATMs and branches

While the above analysis reveals and compares key location factors of ATMs and branches, much areal variation in the relationship remains concealed. Identification of such variations can provide meaningful insights into understanding location factors. For this purpose, standard residuals were examined to geographically portray the spatial variation. In essence, residual is the absolute proportion of Y not explained by the presence of X in that particular area unit. Each residual magnitude indicates the size of the deviation from the computed average value. Thus, positive values indicate under-predicted districts while negative values indicate over-predicted districts. This study defines residual values under -2 or over +2 as outliers, which will become the foci of the analysis.

Table 5 presents the standard residuals by region. About 80 percent of the residuals lie between -1 and

Table 5. Residual distribution by region

| Standard Residual | Under -2.0 | -2.0~-1.0 | -1.0~0.0 | 0.0~+1.0 | +1.0~+2.0 | Over +2.0 | Total |
|---|---|---|---|---|---|---|---|
| Seoul | | 1 | 10 | 6 | 6 | 2 | 25 |
| Gyeonggi | 2 | 4 | 17 | 6 | 2 | | 31 |
| Incheon | | 1 | 6 | 2 | | 1 | 10 |
| Busan | | | 5 | 9 | 2 | | 16 |
| Daegu | 1 | 1 | 1 | 3 | 1 | 1 | 8 |
| Kwangju | | | 1 | 4 | | | 5 |
| Daejeon | | 2 | 2 | | 1 | | 5 |
| Gangwon | | 1 | 8 | 9 | | | 18 |
| Chungchong | | 1 | 13 | 12 | | 1 | 27 |
| Honam | | 1 | 19 | 16 | | | 36 |
| Youngnam | | 4 | 18 | 18 | 1 | 2 | 43 |
| Ulsan | | | 3 | 2 | | | 5 |
| Jeju | | | 2 | 2 | | | 4 |
| Total | 3 | 16 | 105 | 89 | 13 | 7 | 233 |

+1, indicating that the districts are quite well predicted by the model. Ten districts out of 233 are identified as outliers. Among those, seven regions have standard residual over +2: Seoul Yongsan-gu (2.345), Seoul Seodaemun-gu (2.691), Incheon Joong-gu (2.074), Daegu Joong-gu (2.370), Gyeongbuk Gumi-si (8.224), Gyeongnam Changwon-si (5.612), and Chungbuk Cheongju-si (2.664). Seoul Yongsan-gu, Daegu Joong-gu, and Seoul Seodaemun-gu were under-predicted since large flows of people in these areas occur only during the day. Since the population data is limited in a sense that it only reflects permanent residents, the result is under-prediction of demand for ATMs as well as the number of ATMs in those regions. In the case of Incheon Joong-gu, the fact that 21 ATMs out of 53 are placed in the Incheon International Airport is responsible for the gap. In Gyeongbuk Gumi-si and Gyeongnam Changwon-si, which are typical industrial cities with large-scale industrial complexes, high level of demand for cash services is expected among factory workers. In fact, the location analysis of ATMs in these districts reveals that 70% of the machines are placed in industrial complexes. Since the regression model synthesizes other factor scores, such as population and demand factor in which these two regions score relatively low, the predicted number of ATMs is low compared to the actual value. Lastly, Chungbuk Cheongju-si's residual value is partly attributable to the age composition of the population. Known as the 'city of education,' students comprise 36% of the total population in Cheongju-si. Considering that perception and willingness to use ATMs differ between age groups, this large pool of potential ATM users explains the deviation from the computed mean value.

On the other hand, three regions including Daegu Dalseo-gu (-2.580), Gyeonggi Bucheon-si (-2.997), and Gyeonggi Siheung-si (-2.364) are over-predicted in the analysis. Daegu Dalseo-gu is expected to have a high level of ATMs due to the large influx of residents in the 1990s after the development of large-scale apartment complexes. Yet, over-representation of bank branches in this region compared to other districts is partly responsible for the relatively large deviation. Since most of the branches have ATMs on the outer wall, these ATMs are quite sufficient in number to serve after-hours services, reducing the need for ATMs off the bank properties. The gap between predicted value and real value in Gyeonggi Bucheon-si is attributable to the scale of analysis, since significant differences among three sub-level districts of Bucheon-si were ignored in this analysis due to inadequate data. Lastly, the negative residual value of Gyeonggi Siheung-si indicates that rapid increase in demand for ATMs brought by large-scale development of Siwha Industrial Complex and the concomitant population influx has not yet been sufficiently met.

### 3) Comparison of Spatial Distributions of ATMs and Branches

This section analyzes the distribution of ATMs in comparison with bank branches based on four location factors obtained from the previous section. The previous analysis is appropriate for understanding the overall pattern of ATMs, but is not without limit since no concern is given to special relationship between branches and ATMs. As referred earlier, in reality, ATMs are managed by adjacent branches instead of being operated on an independent scale. To evaluate the influence of branches on ATM distribution, this section uses the location quotient to compare two distributions and attempts to reveal variables that contribute to explaining the differences.

In the first stage, all the districts except Seoul were combined into two groups according to the size of location quotients obtained from earlier section[2]. Districts with ratios between 0.8 and 1.2, where the distribution of ATMs closely reflects that of branches, were left unassigned to consider only the high or low-end values. Among the rest, districts with location quotients under 0.8 were classified as 'Group 1' and those with ratios over 1.2 were classified as 'Group 2.' Group 1, where ATMs are under-presented compared to branches, consisted of 100 districts. Group 2, where the number of ATMs is comparatively high relative to branches, consisted of 43 districts. Discriminant analysis was conducted to find linear combination of factors that best discriminates between these two groups.

The results from discriminant analysis are illustrated in Table 6. The F-ratio from the 'tests of equality of group means' tests the null hypothesis that all group means are equal for each variable. The first three factors are significant at 0.01 level, which implies that there are significant differences between two groups in terms of local economy base, population, and demand. For all the three variables, Group 2 scores higher than Group 1. That is, regions with a higher level of ATMs compared to branches tend to have a stronger economic base, denser population, and more demand-creating facilities such as universities and large stores.

Using the stepwise method and mahalanobis' distance, two out of four independent variables entered the model: population and demand factor. The Wilks' lambda in the final model is 0.665 and the Chi-square (56.253) is significant at 0.01 level, implying that the mean discriminant scores for each group are significantly different. The canonical correlation is 0.636 and explains 40.4 percent ($(0.636)^2 = 0.404$) of the variance in the dependent variable. From the size of the coefficients, it can be inferred that demand factor (0.923) is much powerful discriminator compared to population factor (0.501). Additional information on the correlation between each independent variable and the function, including those that are not selected by the stepwise procedure, are provided by the structure matrix. As can be expected from the results, demand (factor 3) has the highest correlation, followed by population (factor 2), local economy base (factor 1), and local economic power (factor 4).

When compared with the previous results of regression analysis, it appears that while local economy base factor is most influential in determining the absolute size of ATMs in a district, demand factor has the strongest influence on determining the ratio of ATMs to branches. At the same time, local economy base and local economic power factors become insignificant. The primary cause of this difference stems from particular characteristics of ATM management. As described earlier, each ATM is controlled by adjacent branches whose location is mostly influenced by the local economy. Since the establishments in the region comprise the primary demand for financial services offered by branches, the number of ATMs also appears to be closely related to the local economy base factor, even though the typical ATM users differ considerably from those of branch. In this respect, discriminant analysis illuminates other factors that are important in determining the location of ATMs. As reflected by the highest canonical coefficient of demand factor, it can be assumed that the location factors of ATMs and branches differ to some degree when the effects of branches are ignored. Contrary to the rigid con-

Table 6. Results of discriminant analysis

Test of equality of group means

| | Wilks' Lambda | F | Sig. |
|---|---|---|---|
| Factor 1 (Local economy base) | .834 | 27.589 | .000 |
| Factor 2 (Population) | .926 | 11.120 | .001 |
| Factor 3 (Demand) | .725 | 52.619 | .000 |
| Factor 4 (Local economic power) | .998 | .329 | .567 |

Standardized canonical coefficient

| Variable | Standardized Canonical Coefficient |
|---|---|
| Population | 0.501 |
| Demand | 0.923 |

Summary of canonical discriminant function

| Function | Eigenvalue | Canonical Correlation | Wilks' Lambda | Chi-square | Sig. |
|---|---|---|---|---|---|
| 1 | .678 | .636 | .665 | 56.253 | .000 |

straints of maintaining branches, lower deployment and operation costs allow ATMs to be more flexibly placed where demand for cash services is high. These results indicate the possibility that the growing use of technology in the financial sector will gradually reshape the financial landscape.

Lastly, the validity of the discriminant analysis was tested and some of the misclassified regions were examined. The results reveal that the above analysis had a relatively high proportion of correct classification into the two groups, at 82.5% of the total. Within the two groups, Group 1 (93%) had a higher rate of correct classification than Group 2 (67%).

## 6. Conclusion

This paper analyzed the distribution pattern and location factors of ATMs in Korea with an attempt to understand the wide adoption of ICT in the banking sector from a spatial perspective. ATM, which is the typical service channel in the intermediate stage of electronic banking, was chosen as the subject of this study to effectively reveal the dynamic changes occurring across the financial landscape. For the purpose of comparing branch and ATM network, only the ATMs that are placed outside the branch properties were considered.

The distribution of ATMs revealed a pattern concentrated toward the Capital region as well as metropolitan areas and some highly industrialized cities. However, this distribution does not simply duplicate that of bank branches, which is reflected on the regional variation of location quotients. The ratio of the number of ATMs to branches differs among districts, since ATMs are much more flexible than branches in terms of initial setup and operation. The differences revealed in the distribution pattern of bank branches and ATMs suggest dramatic changes occurring in the financial sector brought by the wide use of ICT. Furthermore, this study identified four factors that play pivotal roles in the location of ATMs. The relative importance of location factors differed between ATMs and branches, reflecting the different characteristics of the primary services offered. While the location of the former was more closely related to population and demand factor, the latter was more strongly influenced by the local economy base and local economic power factor. Among those four factors, demand factor served as the most influential discriminator in classifying regions into two groups according to the ratio of ATMs to branches.

This study is only a starting point for further research exploring the role of geography in the dynamic change on the financial landscape brought by advances in ICT. Since this study excludes ATMs operated by non-banking institutions which have been rising rapidly to leadership positions in operating ATMs, it would be dangerous to draw definitive conclusions based only on this study. Also, a clear understanding of more technically advanced methods of banking, especially the internet and mobile banking, is needed to fully address the dynamic transformation occurring throughout the financial sector.

## Notes

1) Five commercial banks include Woori, Chohung, Hana, Jeil, Shinhan bank; six local banks include Gyongnam, Kwangju, Daegu, Busan, Jeonbuk, Jeju bank; two special banks include Nonghyup and Kiup bank.
2) In Seoul where the branch network has already reached the saturation level, the number of ATMs appeared to be in inverse proportion to that of branches. This indicates that the location quotients in Seoul tend to be strongly influenced by the density of branch network than any other factor, thus rendering this region inadequate for the following discriminant analysis. In fact, when the sample data included Seoul, the results of the discriminant analysis turned out to be statistically insignificant.

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