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Delineating Housing Market Areas in the Seoul Metropolitan Area Using a Geo-Computational Approach*

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제갈영**

Abstract : The aim of this paper is to delineate the boundary system of the local housing market areas in Seoul Metropolitan Area. Previous studies on local system of housing market areas can be classified into two groups: housing sub-market approach and housing market area(HMA). After in-depth consideration, HMA approach is selected as a method to delineate local housing market areas in Seoul Metropolitan Area for two reasons. First, housing market areas by nature can be more properly conceptualized as functional regions. Also, it is possible to accommodate housing sub-markets in the framework of HMA. Functional regionalization for delineating HMAs is implemented by using Intramax procedure (Masser and ·Brown, 1975) and 2005-2010 migration data of Seoul Metropolitan Area. According to the percentage of the intrazonal interaction, three of resulting areas, 60%, 70 and 75% are generated. The numbers of regions of respective result are 52, 17, and 9. All resulting areas are spatially continuos and show a certain extent of discordance with the administrative boundaries.
Key Words : Functional regionalization, Migration, Housing market area, Intramax.

요약 : 이 연구의 목적은 수도권 주택시장의 공간적 분화의 특성을 탐색하고 국지적 주택시장의 경계를 설정하는 것이다. 국지적 주택시장에 대한 기존의 연구들은 시장지역을 어떻게 개념화 하는가에 따라서 주택하위시장 접근 방식(Housing sub-market approach)과 주택시장지역 접근 방식(Housing Market Area approach)으로 나뉜다. 두 가지 입장을 모두 고려해본 결과, 아래의 두 가지 이유에 따라 주택시장지역 접근 방식이 더욱 적합한 방식이라고 결론 내렸다. 첫 째, 주택시장지역은 본질적으로 기능지역으로 이해되는 것이 더욱 알맞다. 둘 째, 주택하위시장을 주택시장지역의 틀에서 분석하는 것이 가능하다. 기능지역 구분을 위한 방법론으로는 Intramx(Masser and Brown, 1975)를 채택하였다. 2007년 수도권의 인구이동 데이터를 활용하여 전체내부이동의 비율이 60%, 70%, 75% 인 총 3개의 기능지역 체계를 산출하였다. 각 결과를 구성하는 지역의 숫자는 52개, 17개, 9개이다. 모든 결과는 두 가지 특징을 공통적으로 보여주었다. 우선, 모든 기능지역 체제에서 공간적 연접성이 지켜졌다. 또한 산출된 경계체계는 기존의 행정경계와 일치하지 않았다.
주요어 : 기능지역구분, 이주, 주택시장지역, 인트라맥스

I. Introduction

The aim of this paper is to delineate local housing market areas in Seoul Metropolitan Area and to Axplore the spatial structure of the boundary system. In doing so, previous studies concerning with local system of

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housing market are reviewed to figure out the most appropriate approach and methodology for delineating boundary system of local housing market area. And then, functional regionalization is conducted by an iterative algorithm, Intramax, based on empirical migration data.

A housing unit has not only structural characteristics such as floor space, the number of rooms and so on but also a spatial characteristic, its location. The spatial attribute of housing plays a pivotal role in evaluating the value of a house because it is the location of the housing unit that determines travel time to work and neighborhood characteristics, which are important factors that migrants consider.

Due to this spatial feature of housing, urban housing markets inevitably has segmented and dis-aggregated nature. It is widely accepted that urban housing market is not a unitary market but a set of quasi-independent housing sub-markets in academic circles (Quigley, 1979; Maclennan, 1982; Grigsby *et al.*, 1987; Rothenberg *et al.*, 1991; Goodman and Thibodeau, 1998). Policy makers and planners also recognize that housing markets are heterogeneous and characterized by local issues (Robinson, 2003; Wallace, 2004).

In the housing market research and process of urban planning, understanding the underlying spatial structure of local system of housing market is critical to relevance of their results. Goodman (1998) pointed out that the use of administrative boundaries, which has no functional meaning and is subject to arbitrary change, as approximate local housing market areas could invalidate research conclusion or produce unexpected planning outcomes.

There, however, has not been a consensus on how to define and identify local housing markets. This has been subject to increasing debate (Maclennan *et al.*, 1990). Previous studies on local system of housing market area can be classified into two groups according to their way to conceptualize market area. A group of researchers on the side of housing sub-market approach consider local housing market area as homogeneous region within which the price of standardized housing service tends to uniformity. The researches adopting this context identify housing sub-markets by using statistical method testing whether the price exhibit any statistically significant difference in value.

On the other hand, another group of researchers on the side of housing market area (HMA) approach, conceptualize local housing market area as system of functional region maximizes the ratio of within-region migration to between-region migration. Migration is defining feature of local housing market areas in this light. The studies adopting HMA approach establish the boundary of HMAs based on migration flow matrix by using methods for functional regionalization.

After in-depth consideration, it is concluded that HMA approach is more appropriate approach to delineate local housing market area in Seoul Metropolitan Area. In short, housing market area by nature can be more properly conceptualized as functional region. Also, it is possible to accommodate housing sub-market in the framework of HMA.

Intramax procedure (Masser and Brown, 1975) is utilized as method for functional regionalization. Intramax is a modified version of Ward's (1963) hierarchical aggregation procedure producing a regional system where the ratio of internal transfer is maximized.

There has been a dearth of understanding of housing market area as functional region in Korea. Although numerous researchers have sought to delimit geographical extent of local housing market areas in Seoul metropolitan area, most of them (Kang, 1995; Hong, 1996; Kim, 2000; Ko, 2001; Moon, 2001; Kim and Park, 2003; Kim and Woo, 2004; Jung and Lee, 2007; Kang, 2008; Joo and Park, 2010) adopted housing sub-market approach assuming that the central feature of local housing area is the uniformity of the house price. They identify system of housing sub-markets utilizing statistical methods such as cluster analysis, factor analysis and Chow test.

II. Literature review

1. Unique characteristics of housing market

Compared with other generic commodity markets, housing market is a unique one. Housing units are more durable than other products and are not subject to depreciation caused by aging (Quigley, 1979). And the heterogeneity of housing units can make participants of a housing market view housing units at the same price different (Jones, 2002; Hinck and Wong, 2010).

Location is one of the most important properties that generates the heterogeneity of housing units. The location of housing determines travel time to work and neighborhood characteristics, which are factors being considered deliberately when people search for a new house. According to Brown and Moore(1970), in the decision-making process for relocating their residential location, households attempt to not only address their housing aspirations and requirements with respect to family life-cycle needs but also to take into account the positive and negative features of the local neighborhood. Therefore, a spatial attribute of housing, its location, plays a pivotal role in evaluating the value of a house.

Due to this spatial feature of housing, housing markets are spatially formulated in the city. According to the access-space theoretical model, which has dominated urban housing economics since 1960s, housing market is a single unitary market. Now, it is, however, widely accepted that urban housing systems are highly segmented and are properly conceptualized as comprising a set of quasi-independent local housing submarkets (Quigley, 1979; Maclennan, 1982; Grigsby *et al.*, 1987; Rothenberg *et al.*, 1991; Goodman and Thibodeau, 1998).

The dis-aggregated nature of housing markets has been explored by numerous researchers. There are different theories attempting to explain the spatial formulation of urban housing market. In order to understand the fundamentals of their approaches, it is useful to categorize them into two groups depending on their way to define local housing market area. One group of researchers has sought to identify housing sub-markets where "law of one price" can be applied. They regard local housing market areas as a system of homogeneous regions. On the other hand, another group of researchers has sought to delineate the boundary of housing market areas (HMAs), where the ratio of within-region migration to between-region migration is maximized. Local housing market areas are a system of functional regions for these researchers.

2. Sub-market approach

Some researchers argue that housing market can be analyzed properly within a framework that accommodates the existence of sub-market. There are two types of explanations for the existence of housing sub-market (Jones and Watkins, 2009). Goodman (1978) suggests that housing markets tend to multiple equilibrium. Each sub-market, therefore, has its own level of price. On the other hand, Maclennan *et al.* (1987) explains that housing markets tend to disequilibrium because of the prevalence of market imperfection such as information and search costs.

Irrespective of the rationales for sub-market, the defining feature of housing sub-market is the price differential. Namely, housing sub-markets are the homogeneous regions within which the price of standardized housing service tends to uniformity.

This concept stems from the principle of microeconomics. Stigler and Sherwin (1985) suggested that fundamental definition of a market area by Cournot was "A Market for a good is the area within which the price of a good tends to uniformity, allowance being made for transportation costs". In other words, the geographical extent of the market for an economic good embraces all of demanders and suppliers who trade the good at the same price.

There are standard three stages of statistical test procedure for identifying the existence of housing sub-markets (Jones and Watkins, 2009). Before the test,

potential sub-markets are identified based on a variety of properties. After that, in the first stage of procedure, house prices are decomposed into its component parts. This decomposition is based on hedonic modeling techniques. The hedonic modeling procedure estimates the implicit price of each property attributes. The second stage requires the price of a standardized (hypothetical) property to be compared statistically using a Chow test. The test examines whether the implicit prices for individual attributes exhibit any statistically significant differences in value. Third, a weighted standard error test is also computed to where appear to be statistically significant price differences. The WSE test compares the accuracy of the price estimates generated when sub-markets are identified with those derived from a single model covering the entire market (Schnare and Struyk, 1976).

Schnare and Struyk (1976) found that significant differences in the prices of individual housing attribute in suburban Boston homes using the statistical procedure explained above. Chung (1994) also identified the existence of housing sub-markets in Dallas through Chow test and Wald test. In Korea, many researchers (Ko, 2001; Chung and Lee, 2007; Chung, 2009) also has sought to discover the system of housing sub-market by utilizing this methodology.

3. Housing Market Area approach

Unlike housing sub-market approach, there have been numerous researches that conceptualize a hosing market as a functional region defined by high level of self-containment of spatial interaction. Two types of spatial interaction data are used to delineate local housing market area in this regard, commuting and migration.

According to the access-space theoretical model, households trade off journey-to-work cost for housing expenditure under their budget constraint in order to maximize utility when they search for new house (Royuela and Vargas, 2009). The logic of model implies that a key determinant of resident location is commuting. Consequently, the housing market is defined by TTWA (travel to work area, functional area where the ratio of commuting taken place within each area maximized). In practice, the 1989 Joseph Rowntree housing finance studies of six UK cities defined HMA based on TTWA (Maclennan, *et al*, 1990; Jones, 2002).

It is, however, inadequate to equate TTWA with local housing market area. Rogerson *et al*. (1998) suggested that a potential migrant put more emphasis on their own social well-being and reasonable house prices than employment prospects and commuting time. In addition, the decision making process for migration has become more complicated because the trend towards flexible labor and the increase in female participation rate expedite the division of labor within household (Hincks and Wong, 2010).

Another group of researchers and policy makers suggests that defining feature of a local housing market is a high level of self-containment of both origins and destination of migration. Flows of migrants are the outcome of the interaction between the supply of, and demand for housing with in a market area (Brown and Hincks, 2008). By analyzing spatial patterns of migration, we can grasp the spatial regimes of housing demand and supply. In this regard, housing market area (HMA) can be defined as functional areas within which households search for alternative accommodation without necessarily changing jobs (Hincks and Wong, 2010).

Jones (2002) delineated HMAs within West central Scotland using migration data derived from the Land Registry covering the ten year period 1984-1993. Each record includes details of sale price, origin of mover, property characteristics and so on. He applied the two test criteria in order. The first one is at least 50% internal migration. The second one is in-migration form an adjacent HMA equivalent to less than 5% of the market. As a result, 23 HMAs were identified based on the first criteria. The number of HMAs was reduced to 11 when the principle of weak interaction between HMAs was applied.

Brown and Hincks (2008) established a framework for HMA delineation. Their framework provides three guiding principles. First, the HMA should consider a supply-side and demand-side self-containment measure simultaneously. A supply-side measure is related to origins of movers while a demand-side measure takes account of destination of movers. Each measure can be computed as a ratio of intraflow to total outflow from a specific area (supply-side) / to total inflow to a specific area (demand-side). Resulting HMAs should satisfy both supply-side and demand-side self-containment criteria. They suggested that the adoption of both measures would increase the robustness of the HMA framework when compared with adopting a simpler supply-side measure. Second, the delineation of the HMAs would be more realistic by utilizing information obtained from local estate agents. Through consultation with local estate agents, 43 potential core HMA settlements were identified to be used as a seed ward in functional regionalization procedure. Third, the HMAs should share a similar geographical coverage with TTWA. They demonstrate their framework using data for North West England. Resulting boundary system consists of 25 HMAs satisfy 70% self-containment criteria in both supply-side and demand-side measure. And These HMAs has a close relationship with 23 TTWA delineated by Coombes and ONS (1998) geographically.

4. Evaluating previous approaches

Previous studies concerning delineation local housing market areas has been outlined. After in-depth consideration, HMA approach is selected as the most appropriate framework for delineating local housing market areas.

First of all, the concept of functional region is more suitable for conceptualizing local housing market because housing units are highly heterogeneous by nature. Noronha and Goodchild (1992) explained that "the concept of functional region relates to internal diversity, social and economic heterogeneity, mutual complementary and independence. It is clear that functional regions are a spatial manifestation of social organization." The concept of diversity and heterogeneity are the main features of housing as an economic good. In addition, HMAs have long-run stability while sub-markets could be temporary depending on their cause (Jones, 2002). This difference in temporal durability is considerable in that the main purpose of this paper is establishing a robust boundary system of local housing market area.

There are, however, points to be considered when utilize migration as a defining feature of HMA (Brown and Hinck, 2008). Above all, migration are not a pure measure of demand and are incapable of revealing the scale of excess demand. Also, migration flows relate to individuals rather than to households although households act as main agent in housing. Finally, migration could not take into account unrecorded demands represented by the homeless and inadequately housed.

Lastly, one thing should be noted that the distinction between sub-market and HMA is not so clear in that resulting areas share several common features. Royuela and Vargas (2009) pointed that both market areas can be characterized by a high level of self-containment and by significant difference in housing price. They suggested HMAs have a higher level of self-containment the sub-market. Jones (2002) also noted that making a distinction between HMAs and sub-market is a problem in HMA identification. Furthermore, he suggested in the same paper that the statistical method for sub-market identification, which is data-intensive and impractical, can be replaced by the analysis of intra-urban migration that mirrors the research method of HMA approach.

Studies on local housing market in Seoul metropolitan Area have been taken sub-market approach (Kang, 1995; Hong, 1996; Kim, 2000; Ko, 2001; Moon, 2001; Kim and Park, 2003; Kim and Woo, 2004; Jung and Lee, 2007; Kang, 2008; Joo and Park, 2010). And their geographical focus is on a specific region such as Seoul, a couple of new towns rather than on entire regional system of Seoul metropolitan. Hence, this paper can

give new insights into the local system of housing market by applying the new approach to entire areas of Seoul metropolitan.

III. Methodology

1. Methods for Functional Regionalization

To delineate housing market area (HMA) within which both origin and destination of migrants are highly self-contained, a method for implementing functional regionalization is needed. Jones (2002) developed a housing market algorithm that produces a boundary system satisfying a set of rules. It is possible to develop such an algorithm for regionalization like him. But, we can utilize established regionalization methods proven to be a reliable regionalization tool in the field of geography. Functional regionalization is a branch of geographical analysis; therefore, a variety of method for functional regionalization has been developed and sophisticated by geographers.

Regionalization means partitioning the entire region into a set of small areas theologically. In practice, however, a set of essential spatial units is aggregated into respective regions (Lee, 1999). So, we can entitle methods for functional regionalization to aggregation methods (Koo, 2010). Coombes (2000) classified these methods into three categories, single step procedure, hierarchical procedure and rules-based procedure. The Single step procedure literally conducts single process to aggregate spatial units. Factor analysis, cluster analysis, graph theory fall into this group. Hierarchical procedure involves process of lowering the criterion by stages to produce a result until a satisfying result that meets the criterion is accomplished. Intramax procedure (Masser and Brown, 1975) and the IPFP (iterative proportional fitting procedure) method fall into this category. The rule-based procedure grouping spatial units based on a fixed rule or a set of rules.

Recently, functional regionalization tends to be implemented on GIS software as computational power of a computer has been improved. Martin (2000) tagged this trend as a Geo-computaional approach in region-alization. In this paper, one of the geo-computational method, Intramax, is utilized for delineating HMA.

2. Intramax Procedure

Masser and Scheurwater (1980) suggested that Intramax procedure has merits over the alternatives (the functional distance approach and IPFP procedure) by comparing resulting areas of respective approach. Fischer *et al.* (1993) also noted that Intramax can be easily applied to large and sparse matrices and its resulting areas are explained straightforwardly in terms of the proportion of total flows within groups. And, Brown and Hincks (2008) employ Intramax procedure to delineate HMA in North West England.

Intramax is a modified version of Ward (1963)'s hierarchial aggregation procedure. The purpose of Intramax procedure is "to maximize the proportion of the total interaction which takes place with the aggregations of basic data units that form the diagonal elements of the matrix, and thereby to minimize the proportion for cross-boundary movements in the system as a whole (Masser and Brown, 1975)."

The mechanism of Intramax is as below. Hierarchical procedure has two stages in process of regionalization. The first stage is transformation. After that, spatial units are aggregated in second stage.

Before the process, the interaction matrix (A) whose cell entry (a_{ij}) express degree of interaction between ith row and the jth column should be specified. In the case of this paper, value of a_{ij} is the number of migrants who moved from i region to j region.

In the transformation stage, all of observed value (a_{ij}) are replaced by

$$Z = \frac{a_{ij}}{a^{*}_{ij}} + \frac{a_{ji}}{a^{*}_{ji}},\ i \neq j \qquad (1)$$

where, a_{ij}^{*} is a expected value of interaction between the number of migrants from region to region. a_{ij}^{*} is estimated as follows.

$$a_{ij}^{*} = \sum_{p} a_{p,j} \sum_{q} a_{i,q}, a_{ji}^{*} = \sum_{p} a_{p,i} \sum_{q} a_{j,q} \quad (2)$$

Intramax procedure does not take into account observed values but focus on the relative strength of interactions through this transformation stage.

At the second aggregation stage, the pair of areas for which transformed value is greatest is aggregated. After that, the interaction matrix is reframed into n-1 by n-1 matrix (n is the number of initial row/column). This process continues until all of basic units are combined into only one feature.

The vulnerable point of Intramax procedure is that its resulting area is not the guaranteed optimal solution (Koo, 2010). This is because once a pair region is combined they would not be divided in subsequent process of aggregation. We, therefore, need to be more careful when interpreting its resulting boundary system.

3. HMA self-comtainment

HMAs have been defined as functional areas within which a household substitute one dwelling unit for another without altering job. Hence, The high level of self- containment of migration is a key determinant of HMA. The method for functional regionalzation, Intramax, are prepared. Here, a question arise. What is an appropriate level of self-containment for HMA delineation?

There has not been a unanimous answer for this question. Jones (2002) adopted 50 percentage threshold for HMAs in Scotland while Brown and Hincks (2008) delineated HMAs in England that satisfying 70 percentage threshold. Brown and Hincks also argued in the same paper that the 70 percentage threshold was attractive because TTWA (Coombes and ONS, 1998) had been delimited by using 70 percentage threshold.

Instead of establishing a specific level of self-containment for HMA delineation, the levels of self-containment of each reigon are examined to evaluate their functionality as a HMA in this study. The levels of self-containment of resulting regions exhibit a certain level of spatial variation because the main purpose of Intramax is to maximize the rate of intrazonal interaction in the whole system.

And, this study adopts both a supply-side measure and a demand-side measure as Brown and Hincks (2008) suggested. A supply-side measure is related to origins of migrants while a demand-side measure is related to destination of movers. Each measure can be computed as follows.

$$A_s = A_{intra} / A_{out} \times 100 \quad (3)$$

$$A_d = A_{intra} / A_{in} \times 100 \quad (4)$$

A_s= The supply side self-containment measure of region A

A_d = The demand side self-containment measure of region A

A_{intra}= The number of migrants who move within region A

A_{out} = The number of migrants who move from region A

A_{in} = The number of migrants who move to region A

IV. Application

1. Data and Study Area

The Study area is Seoul Metropolitan Area including Seoul, In-cheon and GyeongGi-Do. The data used to functional regionalization is migration statistics of Statistics Korea based on residential registration in 2005-2010. The basic spatial unit is Eup/ Myeon/ Dong. The number of basic spatial units is 1069 (Seoul: 422, Incheon: 137, GyeongGi-Do: 510). Total number of migrants is 35,237,700 and the initial number of intrazonal interaction is 10,432,230 (29.61%).

Intramax is implemented by Flowmap 7.4 software's 'Continuous Intramax Analysis(van der Zwan *et al.*, 2005)'. Objective function and aggregation procedure used in the software was presented in methodology section. According to the percentage of intrazonal interaction, 60%, 70% and 75%, three of resulting areas are generated. The numbers of regions of respective result are 52, 17 and 9.

2. Results

Three results share two features. First, in spite of the absence of a constraint on spatial contiguity, all resulting areas are spatially continuos, which means all pairs of zones for which Intramax score is the greatest are adjacent to each other. In addition, all resulting areas show a certain degree of discordance with the administrative boundaries. This is consistent with the observation of Meen and Meen (2003) that it is consumer behaviour, and not administrative boundaries, that defines housing market.

1) 52-group solution

The rate of intrazonal migration of 52-group solution (see Fig 1) is 60.02%. The difference between the value of demand-side measures and supply-side measures is slight in most region. The biggest difference is 10.01% of Hwaseong region(50). There, however, is spatial variation in the level of self-containment. Only three regions satisfy 70% threshold, Ansung-Pyeongtaek (52), Nam-gu (incheon)-Dong-gu (29) and Yeoju-Icheon (47). These regions are HMAs that have a great influence upon the decision-making process of potential movers. People live there tend to stay in the region, while

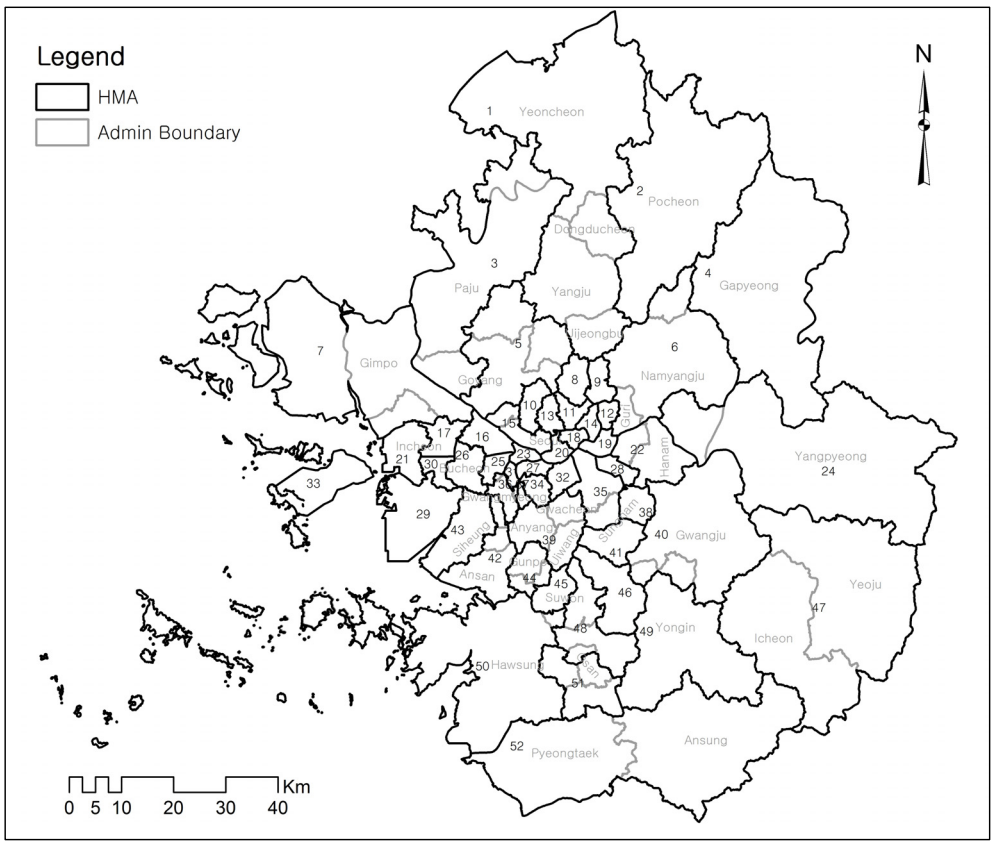

Fig. 1. 52-group solution

movers originated from other regions do not likely to see hosing units in the regions as a set of substitutes for their residential location.

The number of regions satisfying threshold 60%, 50% and 40% are 12, 26 and 11 respectively. As the level of self-containment of the region decreases, their functionality as a housing market becomes weak. For example, northern part of Yeongdeungpo (23) is irrelevant to be considered as a single HMA and should be a part of a more larger HMA.

From this solution, we can grasp several spatial characteristics of local housing markets in Seoul Metropolitan Area. First, HMAs concerning with Seoul area tend to show a lower level of self-containment then Inchoen and GyeongGi-Do. Regions in the bottom twenty of self-containment are HMAs in Seoul except 3 regions (Bupyeong, Hawsung-Suwon and Bundang). It indicates that HMAs in Seoul has open migration pattern. Second, the HMA boundary differs quite from underlying local administrative boundary. Notably, several regions such as Seocho-Gangnam-Sujung (35) and Hanam-Kangdong-Songpa (22) are formed regardless of Do boundary, which is the highest scale of the administrative boundary system in Korea.

Although details of segmented housing market area can be explored by this solution, the variation in the level of self-containment makes the solution less practical as a system of HMAs. To alleviate the problem of spatial variation, more stages of aggregation should be processed.

2) 17-group solution

Fig. 2 shows the boundary system of 17-group solution and Table 3 lists the self-containment of resulting area. The 17-group solution shows 70.33% of

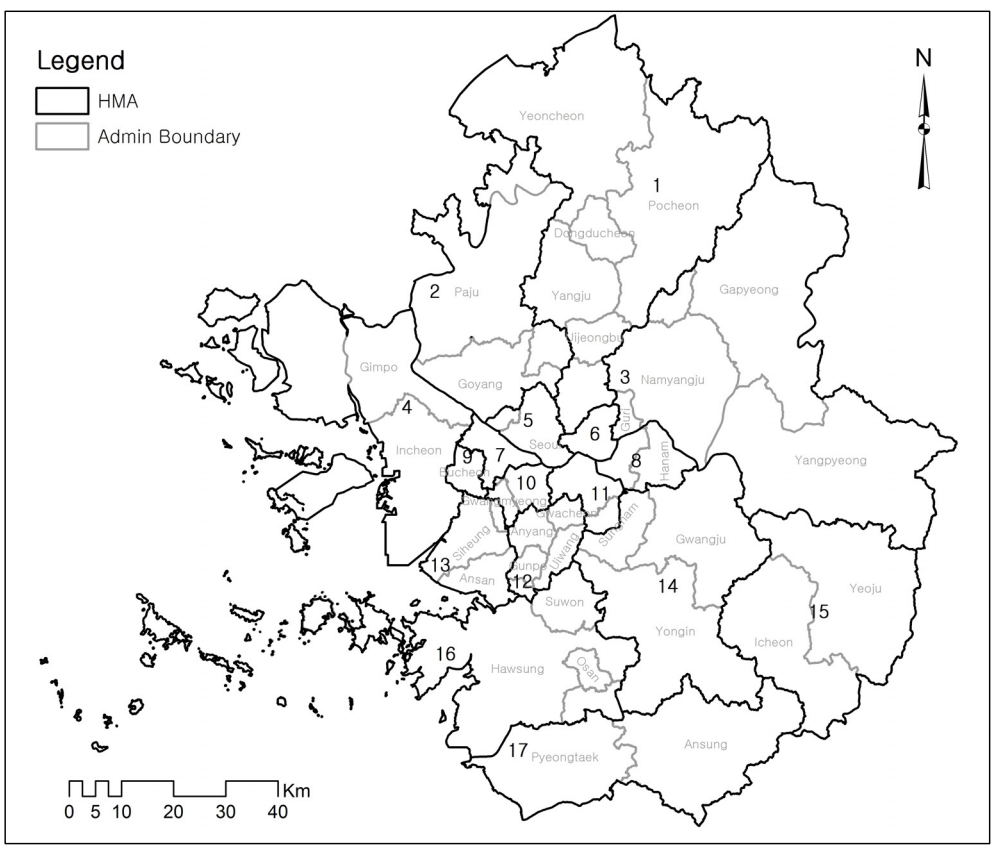

Fig. 2. 17-group solution

intrazonal interaction rate. Ten percentage are improved through 35 steps of aggregation procedure.

Unlike the 52-group solution, in which no region satisfy 80% threshold, a region, Incheon-Gimpo (4, supply-side: 82.69, damand-side: 81.21), exceeds 80% threshold. This region encompasses the whole area of Icheon and Gimpo. Even though Gimpo is a part of GyeongGi-do in administrative sense, its membership in local housing markets belongs to Incheon. The number of regions satisfying threshold 60% and 50% are 7 and 2 respectively.

The HMAs satisfying 70% threshold are seven, Yeoncheon-Pocheon-Dongducheon-Yangju-Uijeongbu (1), Paju-Goyang (2), Siheung-Ansan (13), Gwangju-Youngin-Sungnam (14), Yeoju-Icheon (15), Hawsung-Suwon-Osan (16), Ansung-Pyeongtaek (17). The seven regions mentioned above surround the Seoul. The HMAs in other parts of Seoul Metropolitan Area show relatively intermediate level of self-containment.

In sum, 17-group solution improved in terms of the proportion of the intrazonal interaction. And, the problems of spatial variation in the level of self-containment level allayed partly. Therefore, 17-region solution is more appropriate to be utilized as a system of local housing market areas then former one.

3) 9-group solution

9-group solution (Fig. 3) shows 75.92% of the proportion of intrazonal migration. This solution reveals the system of local housing market area in a large-spatial scale.

Incheon-Gimpo-Bucheon region (3) shows 83.30% of supply side- and 82.52% of demand side- self containment. The six regions, Yeoncheon-Pocheon(1), Paju-Goyang-Eunpyeong (2), Siheung-Ansan-Anyang(6), Gwangju-

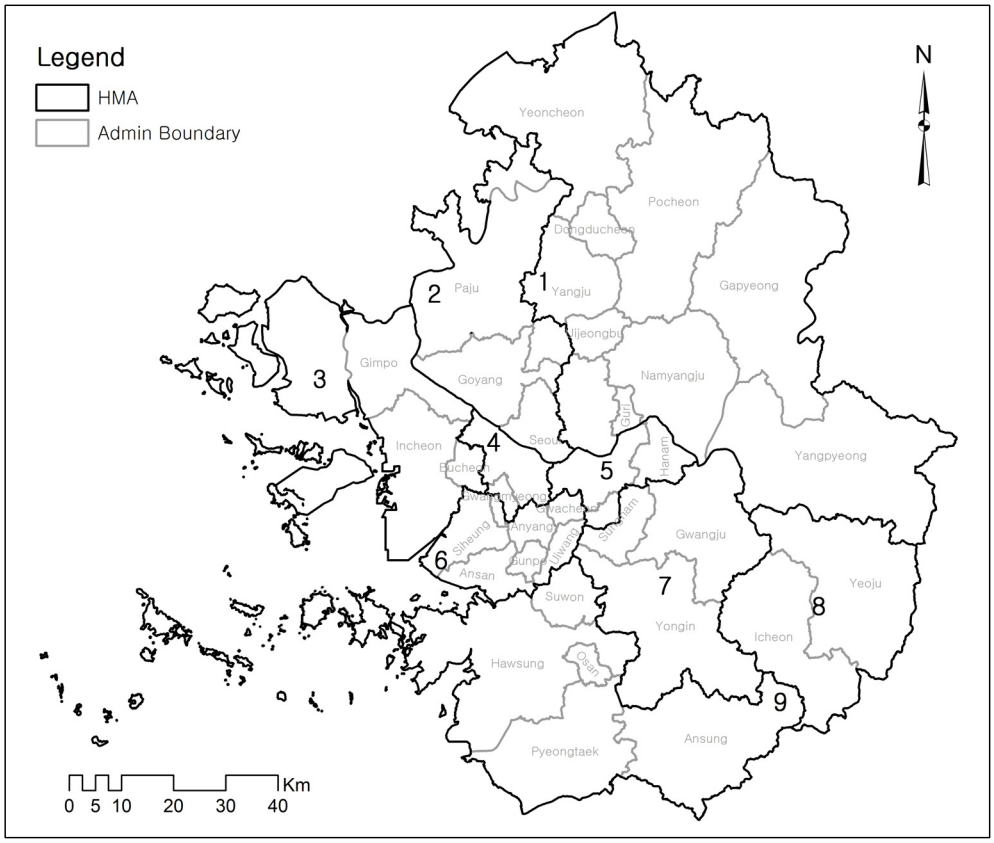

Fig. 3. 9-group solution

Youngin-Sungnam (7), Yeoju-Icheon (8), Ansung-Pyeongtaek (9) covering GyeongGi-Do satisfy 70% threshold. And two region located in southern part of Seoul satisfy 60% threshold. The variation in the levels of self-containments are reduced evidently.

Compared to the boundary system of previous 17-group solution, the segmentation of HMAs in Seoul area is worthy of note. In the boundary system of 17 group solution, HMAs in Seoul area (Group number 5, 6, 7, 8, 10 and 11 in 17-group solution) have little relationship with other regions in terms of geographical extent. In the 9 group solution, however, HMAs in northern part of Seoul are aggregated to HMAs located in northern parts of GyeongGi-Do rather to HMAs in southern part Seoul. It implies that Seoul itself is not a unitary housing market.

The Results are summarized in Table 1. As the number of group decreased, the ratio of intrazonal flow is improved. The variation in the level of self-containment also is reduced as the aggregation proceed. The 52-group solution fails to produce a robust boundary system of HMA because its two third of the resulting areas has significantly low level of self-containment. Compared to 52-group solution, 17 and 9-group solution are more reasonable boundary systems of HMAs.

V. Conclusion

Due to the spatial property of housing units, urban housing markets spatially segmented. There have been two approaches trying to delineate this spatial division. The housing sub-market approach attempts to identify existence of housing sub-market within which the price of the standardized housing unit are equivalent. On the other hand, HMA approach delineates a local housing market area by using functional regionalzation based on migration pattern.

After in-depth consideration, HMA approach and Intramax procedure are utilized as approach and methodology for delineating local housing market in Seoul metropolitan area. Functional regionalization are implemented by using migration data of Seoul metro-politan area 2005-2010. According to the percentage of intrazonal interaction, 60%, 70% and 75%, three resulting areas are generated.

The resulting boundary can be utilized as a regional basis for which future demand for housing estimated. It is shown that resulting HMAs are not consistent with administrative areas. Administrative boundaries have little meaning with respect to housing market operation and their use as HMAs has limited the relevance of housing market analysis and policy development (Cullingworth, 1997). In Scotland, land allocation plans are required to be established in a HMA framework.

However, future research need to consider a number of issues. First, dis-aggregated flow of migrants need to be examined. The migration data used in this paper include none of details about migrants. Demander of housing might be divided into different group according to their age, sex, job, motivation for moving and so on. Different group of migrant might produce dis-aggregated HMAs. It is possible to develop policies targeting specific sub-group by revealing these HMAs (Jones, 2002). Second, It is necessary to examine the relationship between HMA and TTWA empirically. Hinck and Wong (2010) pointed that there have been a distinctive lack

Table 1. The number of regions satisfying threshold of self-containment

# of group	intra flow	above 80%	above70%	above60%	above50%	below 50%
52	60.02	-	3	12	26	11
17	70.33	1	7	7	2	-
9	75.92	1	6	2	-	-

of systematic research analyzing the interaction of housing and labour market. They examined the spatial interaction of HMAs and TTWA as labour market. Third, it is required to reflect revision on methodology of Intramax. Its objective function and aggregation algorithm has been revised for better performance (Hirst, 1977; Slater 1981; Alvanides *et al.*, 2000; Koo, 2010).

Reference

Alvanides, S., Openshaw, S., and Duke-William, O., 2000, Designing zoning system for flow data, in Aikinson, P. and Martin, D. eds., *GIS and Geocomputation. Innovation in GIS 7*, London: Taylor and Francis, 115-134.

Brown, L.A. and Moore, E.G., 1970, The intra-urban migration process: a perspective, *Geografiska Annaler*, 52B, 1–13.

Brown, P.J.B. and Hincks, S., 2008, A framework for housing market area delineation: principles and application, *Urban Studies*, 45 (11), 2225–2247.

Chung, K.S., 1994, Hedonic Models of Housing prices: A critical appraisal of the Assumptions, Ph.D dissertation, University of Texas at Dallas.

Chung, K.S., and Lee, S.Y., 2007, The methodology of distinction of homogeneous housing submarkets and its policy implication, *Korean Journal of Policy Analysis and Evaluation*, 17(1), 193-216.

Coombes, M.G., Green, A.E., and Openshaw, S., 1986, An efficient algorithm to generate official statistical reporting areas: the case of the 1984 Travel-To-Work Areas revision in Britain, *Journal of Operational Research Society*, 37(10), 943-953.

Coombes, M. and ONS(Office for National Statistics), 1998, *1991-based Travel-to-work Areas,* London: ONS.

DTZ Pieda, 2004, *Housing Market Assessment Manual*, London: Office of the Deputy Prime Minister.

Fischer, M.M., Essletzbichler, J., Gassler, H., and Trichtlm G., 1993, Telephone communication patterns in Austria: a comparison of the IPFP-based graph-theoretic and the Intramax approaches, *Geographical Analysis*, 25(3), 224-233.

Goodman, A.C., 1978, Hedonic prices, price indices and housing markets, *Journal of Urban Economics*, 5, 471–484.

Goodman, A.C. and Thibodeau, T., 1998, Housing market segmentation, *Journal of Housing Economics*, 7, 121-143.

Goodman, J.L., 1998, Aggregation of local housing markets, *Journal of Real Estate Finance and Econimics*, 16, 43-53.

Grigsby, W., Baratz, M., Galster, G. and Maclennan, D., 1987, *The Dynamics of Neighbourhood Change and Decline*, London: Pergamon.

Hincks, S., and Wong, C., 2010, The spatial interaction of housing and labour markets: commuting flow analysis of North West England, *Urban Studies*, 47(3), 620-649.

Hong, H.Y., 1996, Study on Market Segmentation of Apartments in Seoul Area, Master dissertation, Department of Real Estate Studies, Konkuk University.

Hirst, M.A., 1977, Hierarchical aggregation procedures for interaction date: a comment, *Environment and Planning A*, 9(1), 99-103.

Jaegal, Y., 2012, Delineating Housing Market Areas in the Seoul Metropolitan Area Using a Geo-Computational Approach, Master dissertation, Department of Geography Education, Seoul National University.

Jones, C., 2002, The definition of housing market areas and strategic planning, *Urban Studies,* 39 (3), 549–564.

Jones, C. and Watkins, C., 2009, *Housing Markets and Planning Policy*, Oxford: WileyBlackwell.

Joo, K.S., and Park, Y.W., 2010, A study on the growth and spatial differentiation of housing market in Yongin city, *Journal of the Korean Geographical Society*, 45(2), 240-255.

Kang, H.J. 1995, A Study on Market Segmentation of

Apartments in Seoul, Master dissertation, Department of Real Estate Studies, Konkuk University.

Kang, P.M., 2008, A Study on the Characteristics of Housing Sub-Markets in Seoul : Forcusing on Housing Tenure and Housing Types, Ph.D dissertation, Department of Public Administration, Kyungwon University.

Kim, B.T., 2000, Determination of spatial boundaries of Seoul housing sub-market, Graduate school of Engineering, Master dissertation, Yonsei University.

Kim, K.S., and Park, J.Y., 2003, The spatial pattern of housing prices, *Journal of the KRSA*, 19(1), 47-61.

Kim, J.Y., and Woo, K., 2004, Housing submarket analysis of the capital region, *The Korea Spatial Planning Review*, 41, 101-112.

Ko, W.Y., 2000, Influence of urban residential environment on multi-family housing prices, Department of Architectural Engineering, Ph.D dissertation, Yonsei University.

Koo, H.M., 2010, Delineating Spatially Constrained Commuting Zones with an Improved Measurement for Functional Regionlization, Master dissertation, Department of Geography Education, Seoul National University.

Lee, S.I., 1999, The delineation of functional regions and modifiable areal unit problem, *Journal of Korea Association of Geographic and Environmental Education*, 7(2), 757-783.

Maclennan, D., 1982, *Housing Economics: An Applied Approach*, London: Longman.

Maclennan, D., Munro, M. and Wood, G., 1987, Housing choice and the structure of urban housing markets, in Turner, B., Kemeny, J., and Lundquist, L., eds., *Between State and Market Housing in the Post-IndustrialEra*, Gothenburg: Almquist and Hicksell.

Martin, D., 2000, Automated zone design in GIS, in Atkinson, P. and Martin, D., eds., *GIS and Geocomputation*, Taylor & Francis, New York, 103-113.

Maclennan, D., Gibb, K. and More, A., 1990, *Paying for Britain's Housing*, York: Joseph Rowntree Foundation.

Masser, I., and Brown, P.J.B., 1975, Hierarchical aggregation procedures for interaction date, *Environment and Planning A*, 7, 509-524.

Masser, I. and Scheurwater, J., 1980, Functional regionalization of spatial interaction data: an evaluation of some suggested strategies, *Environment and Planning A*, 7, 509-523.

Moon, S.O., 2001, Study on the Multi-Factor Sub-markets of Chonse-rental in Seoul, Ph.D dissertation, Department of Economics, Hongik University.

Noronha, V.T., Goodchild, M.F., 1992, 1992, Modeling interreional interaction: implication for defining functional regions, *Annals of the Association of American Geographers*, 82(1), 86-102.

Quigley, J.M., 1979, What have we learned about urban housing markets? in M. Straszheim, M.. and Mieszkowski. P. eds., *Current Issues in Urban Economics*, Baltimore: Johns Hopkins University Press.

Robinson, D., 2003, Housing governance in the English regions: emerging structures, limits and potentials, *Housing Studies*, 18, 249-267.

Rogerson, R., Morris, A.S., Findlay, A.M. *et al.*, 1989, *Britain's Intermediate City: A Comparative Study of Quality of Life*, Glasgow: Glasgow Quality of Life Group.

Royuela, V., Vargas, M.A., 2009, Defining Housing Market Areas Using Commuting and Migration Algorithms: Catalonia (Spain) as a Case Study, *Urban Studies*, 46(11), 2381-2398.

Rothenberg, J., Galster, G., Butler, R. and Pitkin, J., 1991, *The Maze of Urban Housing Markets: Theory, Evidence and Policy*, Chicago: University of Chicago Press.

Ryu, Y.T., 1997, A Study on Housing Submarkets and Residential Mobility : In the New Towns of Pundang and Ilsan in the Seoul Metropolitan Area, *Journal of the Korean Geographical Society*, 32(2), 245-263.

Ryu, Y.T., 2010, Housing Submarkets in the City of Seoul and the Degree of Spatial Disparities in House Prices and Rent Levels across Seoul, 1988-2000, *Journal of the Korean Urban Geographical Society*, 13(1), 89-108.

Schnare, A. and Struyk, R., 1976, Segmentation in urban housing markets, *Journal of Urban Economics*, 3, 146-166.

Slater, P.B., 1981, Comparisons of aggregation procedures for interaction dateL An illustration using a colleage student international flow table, *Socio-economic Planning Sciences*, 15(1), 955-961.

Stigler, G. and Sherwin, R.A., 1985, The extent of the market, *Journal of Law and Economics*, 28, 555-585.

Wallace, A., 2004, *Understanding Local Housing Market? Examining Approaches to Housing Market Analysis*, Office of the Deputy Prime Minister/Economic and Social Research Council Postgraduate Research Programme.

Ward, J.H., 1963, Hierarchical grouping to optimise an objective function, *Journal of the American Statistical Association*, 58, 236-244.

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