■ 論 文 ■

물류계획을 위한 지역유형 추정

Estimation of Area Type for Logistics Planning

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목 차

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요 약

지역유형(area type)은 물류수요의 잠재력(potential)과 밀접한 관련이 있다. 물류계획분야에서 지역유형 변수는 특히 발생모형(generation model)에서 물류유입(freight attraction)을 설명하는 모형변수로, 또한 수송수단선택모형(mode choice model)의 모형변수로 포함되는 것이 최근 선진국의 물류계획 실무분야에서 일반적인 추세이다. 하지만 지역유형은 그 동안 개념적으로 명확히 정의되지 못하였으며, 분석모형의 맥락에서 지역유형의 계량적 추정을 다룬 선행연구는 거의 없었다고 할 수 있다. 이런 이유 때문에 중/장기 물류수요예측 및 물류계획에 있어서 인구와 고용의 변화가 지역유형을 어떻게 변화시킬지에 관한 장기적인 예측을 하는 것이 어려웠다. 따라서 본 연구는 물류시설 SOC사업의 성공적 추진을 위하여 물류수요예측의 신뢰수준을 제고하는 데 있어 꼭 필요하고 시급한 연구로서 지역유형(area type)을 고려한 물류수요의 잠재력(potential)분석 방법을 제시하였다.

Area type is often used in freight demand analysis and logistics planning models. For example, in freight transportation planning, area type variable is most often commonly used in freight generation (attraction) model. Yet a reliable, forecastable and measurable definition of area type is generally not documented. In fact, there is little literature on the subject of predicting area type in the context of freight planning models. This can be troublesome when applying models to long-range logistics planning where significant changes in population and employment result in changes in the general character of an area. Through the use of Discriminant Model, GIS (Geographic Information System) analysis and Delphi methods, this paper presents the successful exploration for a quantifiable means of determining area type.

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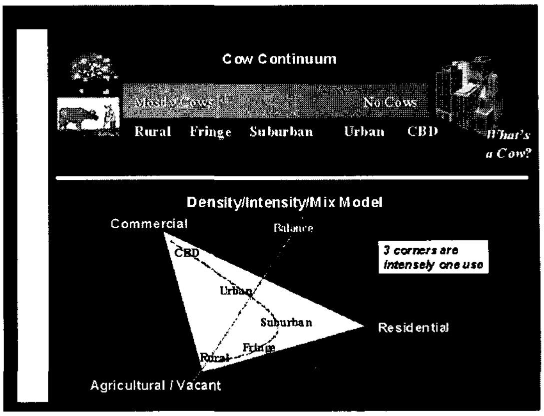
Ⅰ. Introduction

Many freight demand models use area type variables to help predict freight demand potential. A necessary part of the study was to determine what constituted area type. In this paper we address the subject of predicting area type in the context of freight planning models. In real world of the logistics facility planning practices, research should be focused on the modeling process of how to estimate the area types in the context of the logistics facility planning such as industrial area, port area, recreational area, and etc.

For this study, two conceptual frameworks were developed to potentially explain changing area : the "cow continuum" and the "density/intensity/mix" model. Graphically depicted in 〈Figure 1〉, each of these frameworks highlights the same issues in different ways. The first framework is what we called "the cow continuum". What this is suggested in this framwork is that development occurs along a relatively direct continuum from rural/agricultural uses to high-intensity commercial development. Where any given area is along the continuum determines its area type. The second framework is more complex. It suggests that density(the amount of development in a given area in a particular use / size of the area in a particular use), intensity (the sheer amount of a particular use), and mix of use all determine area type.

Typical development patterns occur along the dash line in 〈Figure 1〉 (Rural → Suburban Fringe → Suburban → Urban → CBD). Unlike the "cow continuum", however, development can occur from a rural area type condition at any speed (not necessarily continuously) to one of the other area types. For example an intensely agricultural use can suddenly become completely residential, as in the development of a large scale residential subdivision. This framework was called the "density/intensity/ mix" model.



〈Figure 1〉 Conceptual Framework for Area Type Model

Given these two conceptual and somewhat complimentary frameworks of area type evolution, we began the exploration for a mathematical model to explain what attributes would cause planning professional to classify any given area into a type. Because the basic unit of analysis was the freight analysis zone (FAZ), several fundamental principals were deliberated and agreed to in order to develop the basis of analysis. Area type is determined not only by the uses within a FAZ but by uses in adjacent zones as well. For example, if a FAZ in the downtown happened to be vacant and awaiting redevelopment, it still should be classified as CBD (central business district) regardless of the lack of use.

- Measures of density, intensity and mix of use should be both empirical and "orecast-able." Current area type would be the dependent variable in the estimation process.
- As area type designation is an experience-based, subjective, and nominal level variable, many different opinions would be considered and many different reviews would be necessary to complete the base year area type inventory.
- Independent variables would be derived from available MPO (Metropolitan Planning Organization) freight demand model

socioeconomic data and local tax appraiser GIS data.

II. Literature Review

Area type is a common variable in freight demand models. It is often used in freight generation and mode choice and is sometimes used in other steps. The Oregon DOT in US documents the two most common approaches used to classify area type in a freightdemand model. The first, and most common, is to, through the experience of a professional in the area (user defined). The second most common approach is to define area type through some sort of simple density function. In fact, area type is a convenient variable in that it captures many effects. It is for this reason it appears in many, if not most freight demand models. Because models are often "borrowed", the transferability of variables such as area type is difficult to assess because definitions of area type are often not clear.

Depending on how it is defined, area type may also be difficult to forecast for a given urban area. A common approach to defining area type that is difficult to forecast is through general descriptions. Here area type is described with phases like "typically varies from" and "is sometimes mixed". While these types of descriptions are often true, they are not necessarily easy to agree to nor transferable to other urban areas. It is often unclear where one area type ends and the next begins.

Some areas have given more specific definition to area type. In North Central Texas, area type is based on a measure of density. An activity density based on the combined population and employment density is calculated, with employment factored by the regional population/employment ratio; five area types are used :

- Area Type 1 = Central Business District Density 〉 125 per acre)
- Area Type 2 = Outer Business District Density = 30-125 per acre)
- Area Type 3 = Urban Residential (Density = 7.5-30 per acre)
- Area Type 4 = Suburban Residential (Density = 1.8-7.5 per acre)
- Area Type 5 = Rural(Density 〈 1.8 per acre)

For a research project for Michigan, a survey team established four categories of area type based on some quantitative measures of density :

- Area Type 1 = 10+ employees per acre of usable land
- Area Type 2 = 〈 10 employees and more than five dwelling units per acre of usable land
- Area Type 3 = 〈 10 employees and from 0.5 to 5.0 dwelling units per acre of usable land
- Area Type 4 = 〈 10 employees and less than 0.5 dwelling unit per acre of usable land

Though the Texas and Michigan measures of area type are both quantitative, it is not clear from all the reports and documentation what the empirical basis was for classifying area types or how well these measures fit the character of the local area. None of approaches found in the literature met the fundamental goals of the project set out early on, particularly the goals of describing the general character of an area through empirical, forecast-able variables based on the character of a FAZ and its neighboring zones. It is for this reason that the researchers decided to try to pursue a locally developed, empirically-based definition of area type.

III. Data Set Development

One thing that distinguishes this study from many others on the same topic is that, early on, the researchers recognized the need for significant input from the local freight transportation planning community. It was through this approach that the data set necessary for the estimation process evolved. It was also through this approach that the criteria for assessing any resulting predictive model were established.

The first test would be that the model was manageable, i.e. that it must have a reasonable number of independent and dependent variables that were based on readily available data. The second test was that it was understandable to the general freight transportation planning professional community. The next and most important test was that it was forecast-able. The final tests were that it was both reliable and believable.

Given these overall criteria for the model, the first part of the data set development focused on developing and specifically defining area types in the Tampa Bay Region, Florida, US which is the dependent variable for the study-area type. Because of the definition of area type varies based on personal experience and perception, it was decided by the research team that a Delphi approach would be most appropriate to develop the dependent data. Major steps in the process were as follows :

- FAZs were assigned to one of five possible designations : CBD, Other (mature) Urban, Suburban, Suburban Fringe and Rural
- The maps were collected by the study team and coded into ArcView maps.
- The study team and the professionals assembled to review their collective areas of agreement and disagreement. Professionals had to defend and explain why they classified areas a particular way and why their map differed from other those produced by other professionals in the group.
- A final classification was established based for each FAZ based on the most persuasive arguments and the concurrence of the group. However, "gray areas", those FAZs that could have reasonably fallen into one of two different classifications depending on how strongly you weighed a particular consideration, were noted. These areas would be important in assessing the performance of each estimation procedure.

It was through the process of explaining and defending decisions to classify a particular FAZ or group of FAZs into an area type that the two basic constructs for the model were developed; the "cow continuum" and the "density/intensity/ mix" model. It also provided the basis for selecting potential independent variables. The independent variables were identified that were available locally and that captured the "density/intensity/mix" character of each FAZ :

- the percent of land in residential use
- the percent of land in commercial retail use
- the percent of land in industrial use
- the percentage of land undeveloped or in agricultural use
- the average dwelling unit density
- the average employment density
- the ratio of employment density to dwelling unit density

To develop the independent variables for the estimation data set, summaries were prepared from the regional base map. The base map is an assembly of key geo-spatial information from local property tax appraisers. Because the map includes current and future land use designations, it could serve as the basis of both the estimation data set and future forecasts.

Ⅳ. Model Selection and Specification

The hunt for a mathematical definition of area type is in many ways like hunting for the mathematical definition of an aroma in that it smells a bit different to everyone. Because area type is a purely nominal level variable, the appropriate techniques must be used to test the model. In this case we felt that the Discriminant Model would be most effective. This is because the area type group membership is truly categorical (nominal). If group membership was based on variables with continuous values, (for example, high income versus low income) a regression model would have been more appropriate.

Discriminant model is useful for situations where one wants to build a predictive model of group membership based on observed characteristics of each case. The model generates a discriminant function (or, for more than two groups, a set of discriminant functions) based on linear combinations of the predictor variables that provide the best discrimination between groups. The functions are generated from a sample of cases for which group membership is known; the function can then be applied to new cases with measurements for the predictor variables but unknown group membership.

The Discriminant model identifies the linear combination of empirically derived quantitative variables that best captures the differences among known groups. The linear combination of variables (Discriminant Function) nevertheless looks like a typical regression equation.

$$D = a + b1 \times X1 + b2 \times X2 + \cdots$$

Where, X : Predictor variable
D : Discriminant score
b : Classification coefficient
a : Constant in the model

What makes the procedure directly applicable to this analysis are its basic assumptions and characteristics :

- The value D (Discriminant scores) will differ for groups.
- Classification Function Coefficients, estimated by the procedure, are used to assign cases (FAZ) into a group (area type).
- Each case is predicted as a being member of the group in which the value (Discriminant score) of its classification function is largest.
- Each group should have a multi-variate normal distribution with same covariance matrix.
- Cases should be independent.
- Group membership is assumed to be mutually exclusive (i.e., no case belongs to more than one group) and collectively exhaustive (i.e., all cases are members of a group).

V. Model Estimation and Results

Because area type was to be used to help determine freight attractions potential, several combinations of variables and area types were evaluated. The goal was to find the best combination of variables to explain area type and the best combination of area types to explain freight attractions. As a result, the process was iterative and required assessment of fit to both equations. As part of this iterative process, several combinations of the five originally designated area types were evaluated based on statistical fit and thematic mapping of results :

- Scenario 1 : CBD, Urban, Suburban, Suburban Fringe, Rural
- Scenario 2 : CBD, Urban & Suburban, Suburban Fringe, Rural
- Scenario 3 : CBD, Urban, Suburban & Suburban Fringe, Rural
- Scenario 4 : CBD, Urban, Suburban, Suburban Fringe & Rural
- Scenario 5 : CBD, Urban & Suburban, Suburban Fringe & Rural

Additionally, each scenario was evaluated using independent variables that were averages of each zone and some number of its neighbors. Early testing and mapping of results showed that, without considering the conditions of neighboring zones, area type predictions were sometimes "checker-board" in appearance. The final testing of the scenarios was completed using an average of a zone's characteristics plus

〈Table 1〉 Model Estimation Classification Results

		Scen 5 Area Type	Predicted Group Membership			Total
			1CBO	2 Urban & Suburb	3 Sub Fringe &Rural	
Original	Count	1CBO	46	29	0	75
		2 Urban & Suburb	8	1133	71	1212
		3 Sub Fringe &Rural	0	129	425	554
	%	1CBO	61.3	38.7	.0	100.0
		2 Urban & Suburb	.7	93.5	5.9	100.0
		3 Sub Fringe &Rural	.0	23.3	76.7	100.0

Note : 87.1% of original cases correctly classified.

those of its three nearest neighbors. The final combination of variables that quantitatively measured the three indicators of area type identified through the Delphi portion of the study was as follows :

- employment density per acre (density)
- dwelling unit density per acre (density)
- percentage of land in agricultural use or vacant (intensity)
- percentage of land that was in the combined total of commercial and industrial use (intensity)
- ercentage of land in residential use (intensity)
- ratio of employment to dwelling units (mix)

〈Table 1〉 presents the estimation fitting results. 〈Table 2〉 (model estimation results) shows that the overall the model correctly classified more than 87% of the cases. The numbers and percentages along the diagonal in 〈Table 2〉 indicate the level of fitting power of the model. For example, the model estimates 61.3% of CBD area as CBD, 93.5% of Urban & Suburban area as Urban & Suburban, and 76.7% of Suburban Fringe & Rural area as Suburban Fringe & Rural. Most importantly, none of the cases identified by the professional community as CBD were classified as rural/ suburban fringe and vice versa. The cases that were not correctly classified were often those identified during the Delphi process as in the "gray areas" between area types.

Another important test of the model was

〈Table 2〉 Classification Function Coefficient

	Scen 5 Area Type		
	1CBO	2 Urban & Suburb	3 Sub Fringe &Rural
% Combined Com/Ind LU of TAZ and Surrounding TAZs	.605	.681	.577
% Residential LU of TAZ and Surrounding TAZs	.37	.619	.555
% Agricultural LU of TAZ Surrounding TAZs	.353	.427	.495
Emp Density of TAZ and Surrounding TAZs	.237	-1.6E-03	-5.988E-03
DU Density of TAZ and Surrounding TAZs	1.713	.675	.121
Ratio Emp/DU of TAZ Surrounding TAZs	-1.5E-03	2.46E-03	1.352E-03
(Constant)	-27.515	-23.483	-19.178

Note : Fisher's linear-discriminant functions

whether the results were understandable to the transportation planning community. 〈Table 2〉 presents the coefficients resulting from the analysis. The results are generally very intuitive. In and of itself, the amount of land in commercial or industrial use is not a particularly strong variable for any given area type, but it is strongest for the older, more mature urban/suburban. Employment density was weighed the strongest in the CBD while the amount of land in agricultural or vacant status was most important in the suburban fringe and ruralarea type. Higher dwelling unit density was strongest in the CBD and urban area type classification and least in the suburban fringe/rural area type classification. The mix variable (ratio of employment / dwelling unit) plays a weak role in all area type cases.

Ⅵ. Conclusions

This work has shown that it is possible to develop a quantifiable method of determining area type. The method is attractive because it meets several tests that are important to planners and modelers : (1) It is understandable, relying on generally accepted concepts about what differentiates one area type from another. (2) It is simple, requiring only a relatively few, readily available variables and relying on a simple and easily interpreted Discriminant analysis technique. (3) It is forecast-able, allowing users to reflect changes in area type as an area develops over time. (4) It is reliable and believable, in that its results generally reflected the collective ideas and perceptions of a wide variety of freight transportation planning professionals.

The study builds on a significant amount of research over the years for basing area type on density of development. However, this study recognized and built upon the intuitive perceptions of planners that density alone cannot adequately define area type in all situations. Drawing upon the experiences and ideas of a wide body of professionals, this study recognized that, in addition to density, the mix of activities and the sheer volume or magnitude of activity are also important in determining how an area functions and is perceived.

One important finding of the study was the significant improvement in the results that came from basing area type on the overall average conditions of the FAZ and its neighboring zones rather than just on the characteristics of the individual FAZ. This resulted in much smoother boundaries for area types across the region and eliminated the spottiness or checker-board patterns that often result from looking at each FAZ independently. The results reflect the fact that area types tend to shift gradually as one moves across the region rather than abruptly from zone to zone. The results were much more believable and acceptable.

Finally, the method proposed in this study needs to be evaluated and expanded to apply it to a real world of the logistics facility planning practices in Korea. A future research should be focused on the modeling process of how to apply the proposed method to the area types in the context of the logistics facility planning such as industrial area, port area, recreational area, and etc.

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