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Empirical Analysis for Modeling Spatial Variation in Right of Way Acquisition Durations

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The objectives of this research are to analyze empirical Right of Way (ROW) acquisition process records to quantitatively determine key project features influencing ROW acquisition durations and examine the spatial variation of the features' effects. This research used database of 495 projects that finished ROW acquisition process between the year 2010 and 2019 by Georgia Department of Transportation. The multiple linear regression is performed to identify significant variables that impact acquisition duration. Then, the geographically weighted regression analysis is conducted to examine spatial variations of variables' effects across the geographical locations. Acquisition durations tend to increase as the number of parcels and the average cost estimate per parcel increases, the design is completed by consultant or regional office, and the type of work is roadway and widening projects. The analysis results indicate that variables' effects vary throughout areas of the state. Therefore, ROW practitioners should consider giving different weights to project features depending on the project's location when setting the ROW acquisition schedule to reduce risks of schedule delays and cost overruns. It is anticipated that findings of this research will provide insights to ROW practitioners on how to improve ROW acquisition timeline estimations and better manage the risks.

Key Words: Right of Way, Geographically Weighted Regression, Spatial Analysis, Project Management

Introduction and Background

The Right of Way (ROW) acquisition is to acquire real properties that are required for transportation projects. It is critical to complete acquiring ROW in a timely manner so that the transportation project can move forward in the scheduled time (Aleithawe, 2017). Failing to acquire required ROW on time can directly affect the schedule of construction and cause delays and cost overruns in transportation projects (Jeong et al., 2016). Therefore, it is important to accurately estimate the ROW acquisition duration to mitigate the risk of project being delayed. However, estimating ROW acquisition timeline beforehand is often difficult because of the complex nature of the process (Chung et al., 2021; Dyke et al., 2020). Specific project characteristics and unique surroundings make it challenging to precisely forecast ROW acquisition timeline (Sohn et al., 2009).

Because transportation projects are different in many dimensions, their unique project features should be considered when setting the acquisition timeline. For example, the number of parcels and number of relocations would directly affect the amount of workload to complete acquisition process (Chung et al., 2021). The location of projects, such as urban or rural areas, would generate different challenges in the acquisition projects (Jeong et al., 2016). The project type (e.g., widening, bridge, intersection improvement, etc.) is an important feature because the type of parcels to acquire would differ (Sohn et al., 2014). It is needed to understand how unique project characteristics affect the ROW acquisition duration to better estimate timelines of the process. Previous studies contributed to identify the barriers that impede facilitation of ROW deliveries and to improve the estimation of the ROW acquisition duration.

Gibson et al. (2006) examined detailed records of 45 projects, including letters, faxes, appraisal reports, negotiation reports, and communications between internal and external entities, to find which factors caused delays in the ROW acquisition process. The following incidents were found to cause delays in ROW acquisition: (1) disputes on compensation and pricing; (2) title curative problems; (3) third-party delays; (4) parcel characteristics, and owner-initiated and improvement delays; (5) environmental sensitivity and expert witness delays; (6) legal activity causing delays; (7) utility delays; (8) design change or revision delays; and (9) terrain features dispute causing delays.

Jeong et al. (2016) conducted surveys and interviews to identify barriers that exist in the ROW acquisition process. The authors found that the barriers that transportation agencies faced were caused by four roots: (1) uncooperative work environment; (2) lack of tools and methods; (3) distrust of property owners; and (4) adverse effect of eminent domain law.

Waters (2000) found the barriers and obstacles that hinder expedient ROW acquisition process, by conducting a survey of transportation agencies. The barriers and obstacles found were (1) late design and ROW plan changes and revisions; (2) unrealistic project schedule; (3) problems in coordination between agencies; (4) insufficient trained ROW staff; (5) consultant problems; and (6) ineffective use of technology applications.

Chung et al. (2021) conducted survey of ROW representatives in thirty-six State Department of Transportations (DOT) to identify current management practices developed and explore possible ways to expedite the process. A part of their survey was dedicated to find the importance of factors considered in setting the ROW acquisition timeline. The survey results indicated that the top five factors considered important are (1) number of parcels to acquire, (2) needs for relocation assistance, (3) project size in monetary value, (4) needs for appraisers, and (5) project type.

Aleithawe et al. (2012) performed regression analysis using previous Mississippi Department of Transportation highway construction projects to identify the factors contributing to acquisition duration. The authors found that the significant factors that increased the acquisition duration were: (1) number of parcels; (2) number of parcels acquired by condemnation; and (3) number of revisions. The authors also developed a regression model using the identified factors to estimate the ROW acquisition durations.

Multiple researches have been conducted to identify factors that affect the ROW acquisition duration and find ways to make the acquisition process more efficient and expedient. However, only limited studies have been done to empirically identify which project features affect the ROW acquisition duration and quantitatively measure the importance of variables. Moreover, gaps in knowledge remains on finding if the effects of variables would vary depending on the projects' locations. The objective of this research is to analyze empirical ROW acquisition process records to quantitatively determine key

project features influencing the ROW acquisition durations and examine the spatial variation of the effect of variables. The methods introduced in this paper can be applied by any transportation agencies to evaluate which project features affect their ROW acquisition duration and examine how the effects vary throughout locations. Quantitatively evaluating the influence of key project features and their spatial variation throughout locations will give transportation agents insights on how to improve their ROW acquisition estimation models so that they can better manage ROW acquisition risks.

Research Methodology

Data Preparation

This research used the database of 495 projects that finished ROW acquisition process between the year 2010 and 2019 by Georgia Department of Transportation (GDOT). The project descriptions were found in the GDOT Preconstruction Status Report. The duration required to perform ROW acquisition process was used as the dependent variable. Literature review and discussion with subject matter experts associated with GDOT have been done to identify the factors that affect the ROW acquisition timeline. Thirteen variables were selected to be the explanatory variables for the analysis in this research. The descriptions of the variables and justification of the selections are listed in Table 1.

Table 1

Description of variables selected for the analysis

Variable	Descriptions	Source
Number of Parcels	The number of parcels required to acquire for a project is a significant factor to estimate the workload and duration. It was also used for building models to predict acquisition timeline in previous research.	Aleithawe et al. 2012; Chung et al. 2021; Sohn et al. 2014
Number of Relocations	The number of relocations provides the number of parcels that need relocation assistance. This factor was found to be essential when setting the acquisition timeline.	Gibson et al. 2006; Sohn et al.2014
Number of Condemnations	This variable describes the number of condemnations needs to be filed. Filing condemnation can significantly affect the acquisition duration and cause delays in the acquisition duration.	Aleithawe et al. 2012; Caldas et al. 2011
Average Cost Estimate Per Parcel	This represents the average cost estimate per parcel. The cost estimate per parcel would affect the duration depending on the funds available for the ROW acquisitions. The annual ROW budget was found to be one of the key drivers affecting ROW acquisition duration.	Sohn et al. 2014
Environment Document	The level of environmental document needed to be completed (National Environmental Policy Act; Georgia Environmental Policy Act). It was found that the type of environmental document needed to be completed affects the ROW acquisition timeline.	Waters 2000
Design	It defines which office completed the design process (central office; regional office; consultant). The quality of designs would influence the ROW acquisition duration because the revisions in design was found to be one of the significant factors that contributed to delays in ROW acquisition. An	Aleithawe et al. 2012; Gibson et al. 2006

	assumption was made that the quality of design is dependent on the office that prepares the design.	
Urban Location?	This variable indicates if the project is held at urban location or not. The acquisition timeline has been found to be impacted by the geographic location (e.g., urban, suburban, or rural) because the acquisition environment would differ depending on the location of a project.	Jeong et al. 2016
District	This identifies which DOT district the project is held in (District 1 to 7). The characteristics of district, such as district ROW staff size and district annual ROW budget, would impact the duration it takes to acquire ROW.	Sohn et al.2014
Type of Work	The work type of project (bicycle/pedestrian facility; bridges; interchange; intersection improvement; operational improvement; roadway project; roundabout; signal; widening; others) would affect the types of parcels that need to be acquired.	Chung et al. 2021; Sohn et al. 2014
Program Type	This variable provides information about the program type of the project (enhancement; new construction; reconstruction; replacement; maintenance; safety). The type of projects was identified to be a significant factor in setting the ROW acquisition timeline.	Sohn et al. 2014
Length of Projects	The physical length would determine the variations in the surrounding environments and in the types of parcels. Higher variations in the project environment may increase the complexity of the acquisition process and cause longer durations.	Discussion with subject matter experts
Acquired by Central Office?	This variable indicates if the ROW acquisition process was performed by the central office or the regional office. The durations might depend on which office performs the acquisition.	Discussion with subject matter experts
Let with Other Projects?	This variable indicates if a project is planned to be let with other projects. If two or more projects are planned to be let together, their schedule may be influenced by one another.	Discussion with subject matter experts

After selecting the variables for the analysis, the multicollinearity between explanatory variables were examined. Substantial degree of multicollinearity exists between variables when those are related to each other (Bowerman et al., 2005). High multicollinearity can inflate the variances of affected variables and generate less certain results among the variables. The multicollinearity can be measured using the Variance Inflation Factor (VIF) value. The variables with VIF value larger than 10 were considered to have severe degree of multicollinearity (Bowerman et al., 2005) so that they were removed from the analysis. The removed variables were reconstruction and replacement from the program type and bridges from the type of work.

The dependent and explanatory variables were standardized for the data analyses. Standardization adjust each variable's scale and unit into a common scale and unit (Karlaftis et al. 2010). The importance of explanatory variables to explain the variance of dependent variable can be found by comparing magnitudes of standardized coefficients.

Data Analysis

The multiple linear regression and geographically weighted regression were conducted to examine the relationship between the project features and the ROW acquisition durations. The significant variables were found from the multiple linear regression and evaluated how those variables affect the acquisition durations. With those identified significant variables, the geographically weighted regression was performed to capture the spatial variation of relationships between the dependent and explanatory variables. The coefficients calculated from the geographically weighted regression were adjusted throughout the geographical locations to build regression models for local variables (Düzgün H., and Kemeç S. 2008). Plotting the varying coefficients of significant variables helps to find how the effect of explanatory variable changes throughout the locations.

Results and Discussions

The model generated from the multiple linear regression and the geographically weighted regression is defined as the following equation.

$$\begin{aligned} ROW\ Acquisition\ Duration = {} & a_0 + a_1[Number\ of\ Parcels] \\ & + a_2[Average\ Cost\ Estimate\ Per\ Parcel] + a_3[Consulatnt\ Design] \\ & + a_4[Local\ Design] + a_5[Roadway\ Project\ (Type\ of\ Work)] \\ & + a_6[Widening\ (Type\ of\ Work)] \end{aligned}$$

where, a_0 is a constant and a_i is a coefficient of the *i*-th explanatory variable. The coefficients computed from the multiple linear regression are global, meaning that the coefficients apply for projects at all locations, while the coefficients found from the geographically weighted regression vary throughout the locations. Since the variables were standardized, it means that the dependent variable changes in a_i standard deviation when the i-th variable is changed by one standard deviation. The adjusted R-squared values for the multiple linear regression model is 0.449 while it is 0.454 for the geographically weighted regression.

Multiple Linear Regression

The global coefficients of significant variables identified from the multiple linear regression are listed in Table 2. The acquisition duration is found to increase as the number of parcels and the average cost estimate per parcel increases. In addition, the duration tends to increase as designs are prepared by the consultant or regional office compared to when it was completed by the GDOT central office. Furthermore, the roadway project and widening type of works significantly affect the duration to take longer than other types. The order of significance among variables is: (1) number of parcels, (2) average cost estimate per parcel, (3) consultant design, (4) roadway project, (5) regional office design, and (6) widening.

Table 2

Multiple linear regression analysis results

Significant Variables	Coefficient	Standard Error	P-Value	VIF
Number of Parcels	0.553	0.085	< 0.001	6.419
Average Cost Estimate Per Parcel	0.105	0.039	0.0075	1.379
Consultant Design	0.234	0.089	0.0085	1.544
Regional Office Design	0.302	0.150	0.0443	4.160
Roadway Project	0.594	0.232	0.0107	1.960
Widening	0.285	0.145	0.0499	2.241

The higher number of parcels increasing the acquisition duration aligns with the findings from the previous studies. The survey results and data analyses from previous studies found that the number of parcels is one of the significant variables that influence the ROW acquisition duration (Aleithawe 2012; Caldas et al. 2006; Chung et al. 2021; Hakimi and Kockelman 2005; Sohn 2014). Increment in number of parcels to acquire for a project would increase the overall workload including valuation, negotiation and possibly relocation and condemnation.

The acquisition duration tends to be lengthier as the average cost estimate per parcel increases. The requirement for an appraisal may be waived for low valued parcels to save a substantial amount of time to prepare the appraisals (Jeong et al. 2016). The GDOT allows appraisals for non-complicated parcels value lower than $15,000 can be waived (GDOT, 2018). The ROW acquisition durations may be estimated differently depending on the requirement of preparing appraisals. Furthermore, high price of ROW acquisition can generate a problem due to the funding limitation, which was found to be one of the key drivers that affect the acquisition schedule (Sohn et al. 2009). Sohn et al. (2014) found that the available district annual budget to purchase ROW was a factor that impact the duration to acquire parcels.

The acquisition duration would increase as the designs are prepared by consultant or regional offices compared to when designs are prepared by the central office. From a survey conducted by Waters (2000), all 36 state survey respondents considered that the revisions to the design is a major issue that hinders ROW acquisition process. Moreover, Aleithawe et al. (2012) identified that the ROW acquisition duration increases as the number of revisions increments from conducting data analysis with the historical data collected from the Mississippi Department of Transportation. It is apparent that the maintaining high quality of design is important for minimizing the number of revision and results in expediting the ROW delivery. The information about the number of revisions made for each project was unavailable for this research. The authors made an assumption that the quality of designs would be dependent on the office that performs design process. It would be worthwhile to conduct a further research to examine the number of revisions required for designs prepared by different offices and how those revisions directly or indirectly impacted the acquisition duration.

The roadway and widening projects were found to significantly take longer duration than other projects. The type of parcels and the location of parcels would depend on the type of projects. This result aligns with the findings from previous qualitative studies. The project type was found to be the fifth most important factor when considering the ROW acquisition timeline from the survey with thirty-six state DOT representatives conducted by Chung et al. (2021). Sohn et al. (2014) identified that the project type is one of the drivers that impact the acquisition durations by conducting workshops with forty-

three practitioners who are responsible for ROW acquisition related tasks. Further research would be needed to find which characteristics of roadway and widening projects cause longer duration than the other projects.

Geographically Weighted Regression

The local coefficients of the significant variables found from the geographically weighted regression analysis are shown in Figure 1. As it is shown in the figure, the magnitudes of significant variables coefficients vary throughout the projects' locations.

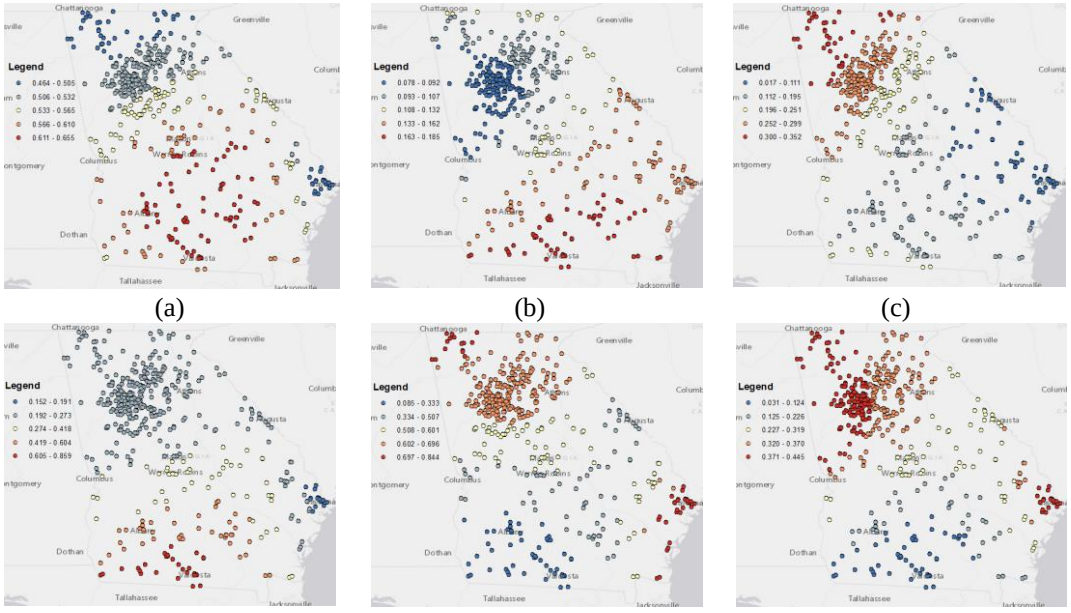

Figure 1. Local coefficients of the significant variables found from the geographically weighted regression: (a) number of parcels; (b) average cost estimate per parcel; (c) consultant design; (d) regional office design; (e) roadway project; (f) widening. (Generated from Esri ArcGIS 2020)

The number of parcels and the average cost estimate per parcel tend to have higher impact at the southern part of the state. The consultant design increases the duration at the northern part of the state while the regional office design increases the duration at the southern part. The roadway and widening projects have the highest influence around the Atlanta and Savannah metropolitan areas. The potential reasons for higher impacts of variables on specific areas would include shortage on human resources, limited available funding, quality of design, performance of district office, difficulty of purchasing parcels to widen or improve existing roadways, and more. The limitation of this research was that the available data did not contain detailed information about the progress of ROW acquisition process for individual project. Therefore, it was difficult to identify which factors are the key drivers that generate the spatial variation of the variables' coefficients. Further research of examining the progress of ROW acquisition process held in multiple areas would be required to clearly understand which factors mainly drive the spatial variation of the variables' effects.

Conclusions

The 495 transportation project data was evaluated to identify which project features should be considered when estimating the ROW acquisition timeline. Among the thirteen variables used in the analysis, the number of parcels, average cost estimate per parcel, design, and project type were found to be significant for explaining the variation of the ROW acquisition timeline. Two categories in both design and project type were found to significantly influence the acquisition duration. In summary, six variables that were found to significantly affect the acquisition duration are (in the order of significance): (1) number of parcels, (2) average cost estimate per parcel, (3) consultant design, (4) roadway project, (5) regional office design, and (6) widening. The analysis results suggest that the acquisition duration tends to increase as the number of parcels and the average cost estimate per parcel increase. Moreover, the acquisition durations would take longer when the design is prepared by consultant or regional offices and if the project type is roadway or widening project.

From the geographically weighted regression analysis results, it is evident that the amount of influence of variables to the acquisition duration vary throughout different areas of the state. Therefore, rather than using a one-size-fits approach to create a baseline timeline for ROW acquisition tasks, setting ROW acquisition timelines differently depending on the project's location can help reduce the risks. Examining the progress of ROW acquisition process held in different areas might help us to identify the key drivers that generate spatial variation of the variables' impacts to the acquisition durations. It is anticipated that the findings of this research will provide insights to ROW practitioners on how to improve methods to estimate ROW acquisition timeline and mitigate the risk of project being delayed. Furthermore, the methods introduced in this paper would provide ideas on how records of other tasks related to transportation infrastructure projects can be evaluated to effectively manage project risks.

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