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Michael Shell, *Member, IEEE*, John Doe, *Fellow, OSA*, and Jane Doe, *Life Fellow, IEEE*

Abstract—The abstract goes here.

Index Terms—IEEEtran, journal, LATEX, paper, template.

I. INTRODUCTION

ESTIMATING the prices of real estate is useful and necessary for taxation, public policy, infrastructure and equality in cities. Medellín is the second city of Colombia, with more than two and a half million inhabitants and a population of over three million in its metropolitan area. It is a focus of development for the country, and construction plays a major role in its dynamics. Most of the development in Medellín is very uniform in its types. The developers do not have a clear idea of what customers want, and thus keep building over the same formula that has worked this far. Universidad EAFIT funded a project with its Research Group in Spatial Economics (RiSE) to assess the real estate prices in Medellín, in order to seek for what it is that costumers value in housing. Geographically Weighted Regression (GWR) was used as a method for the hedonic pricing estimation of real estate in Medellín using only structural variables (size, number of rooms, parking, etc.) to predict total price. Fair estimation results were obtained by using GWR, but some questions arise:

- How successfully can the price per unit area be modeled? Since Area does explain most of the total price, it would be smart to predict square meter prices, as it could be a more robust measure that can overcome how much area shadows other variables in the estimation of the total price. Predictability would be lost, but capability to understand what the public really want could be gained.
- Hedonic pricing theory considers a group of independent variables that can help explain the prices of real estate and are related to the surroundings of a housing unit such as urban form or density, number of parks, accessibility, and quality of transportation, among many others. What contextual variables can be meaningful to improve the actual estimation of real estate prices in Medellín?
- Can clustering techniques reveal housing submarkets? Would they be similar as the one experience has told developers in Medellín so far?
- Does the geographical location of a housing unit absorb other important variables in hedonic pricing theory? How does it relate to them? Which can better explain price?

A. Subsection Heading Here

Subsection text here.

M. Shell is with the Department of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA, 30332 USA e-mail: (see <http://www.michaelshell.org/contact.html>).

J. Doe and J. Doe are with Anonymous University.

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1) *Subsubsection Heading Here*: Subsubsection text here.

II. METHODOLOGY

A. Data and variables

The lengthiest part of this project was to process geographical data from different sources to add to the original data base that was used and analyzed with Universidad EAFIT.

- 1) Housing data was obtained from OIME, Medellín's municipal Real Estate Market Observatory. It can be found online 1. Initially, it has 2003 observations for new and used houses and apartments across the city of Medellín in the year of 2014 (See Figure 1.).

These observations come from appraisals for taxation purposes. They present a reasonable spatial distribution. Notice that there are not many data fields across the center of the city (along the middle line crossing from south to north) because that is a restricted zone for construction, and the less dense zone of the city for residential uses.

The analyzed dataset comprises the following variables. The summary data was calculated after removing atypical values and observations with missing data (absolute z-scores greater than 3):

- Stratum. Categorical index that serves as an indicator for income. Ranges from one to six. In Spanish, from lower to higher income: 1- Uno (90 counts); 2- Dos (253 counts); 3- Tres (479 counts); 4- Cuatro (246 counts); 5- Cinco (179); 6- Seis (114).
- Parking. Boolean factor reflecting whether a residential unit has at least one parking space or not. Counts: 1120 False and 241 True.
- Utility room. Boolean variable indicating individual storage rooms. Counts: 944 False and 417 True.
- Price. In COP. By November of 2015, One US Dollar costs around three thousand Colombian pesos.
- Area. In squared meters.
- Age. In years. Medellín is a relatively new city that has undergone exponential growth especially since the 1960s, without much interest in architectural preservation.
- Spatial coordinates. X and Y coordinates of data points in WGS 1984 projected system.

- 2) In order to account for contextual variables (those that could indicate added value for relatively similar properties given their distance to natural features, public spaces or transportation networks) data was obtained from:

- Medellín's department of Planning Zoning plan 2 (ArcGIS geodatabase). Includes road networks, metro and BRT stations locations, existing parks, among others. The original maps can be seen in

Anexus 1 and Anexus 2. A good amount of geographical processing was needed in order to create variables for nearest distance to features for each of the data points, and to extract the features that were needed in the case of existing green parks and only the main roads in the network (Anexus 3).

III. CONCLUSION

The conclusion goes here.

APPENDIX A

PROOF OF THE FIRST ZONKLAR EQUATION

Appendix one text goes here.

APPENDIX B

Appendix two text goes here.

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The authors would like to thank...

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Michael Shell Biography text here.

John Doe Biography text here.

Jane Doe Biography text here.