DETERMINING THE FACTORS AFFECTING THE GROWTH OF LAND VALUE IN THE GREATER DALLAS – FORT WORTH – ARLINGTON AREA: FOCUSED ON RESIDENTIAL LAND VALUE

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Determining the Factors Affecting the Growth of Land Value in the Greater Dallas – Fort Worth – Arlington area: Focused on Residential Land Value

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Residential land value in Texas has been growing over the past twenty years. In particular, the greater Dallas-Fort Worth – Arlington (DFW – A) area has shown a substantial growth in residential land value. However, the causes that might have contributed to this growth in land value are as numerous as they are varied. This paper examines the issue of continuous rising prices of residential lands in the greater DFW – A area and generates determining causes. Cutting-edge machine learning and graphical approaches are utilized to analyze complex interactions of various factors determining the growth of this land value. Knowing the factors that determine the land value will help various stakeholders in the industry to make better-informed decisions with regards to land transactions. Direct factors affecting land values in greater DFW-A area are past selling price, personal disposable income and change in population.

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CHAPTER I

INTRODUCTION

Population growth in the greater Dallas Fort Worth – Arlington (DFW – A) area has been observed in the past decade, which might have contributed to the increase in residential land value in this area due to increase in demand brought by the increase in population and other various factors. The DFW – A area has experienced a drastic increase in population in the last 30 years approximately at a rate of 2%, ranking as the 4th fastest growing city in the United States in 2014 (2019, World Population Review). This increase in population from migrations and births might have led to an increase in demand for land. The resulting increase in demand caused by the outward shift of the demand curve has led to an increase in price, *cetris-paribus*. There has been raising public concern from this increase in prices where some speculate that the market could be in a "bubble." Although the real estate market goes through different phases, the speculation of a bubble may or may not be applicable. This research seeks to investigate the factors determining the residential land value in a complex economic system where many determining variables are intertwined with each other.

Research Question and Motivation

There has been a continued outcry of the rising prices of land. Policymakers are working tirelessly to come up with sustainable solutions to this problem. However, understanding the problem proved difficult to comprehend because of the complexity of factors affecting the determination of home prices. Take interest rate for example. An increase in interest rate will not only affect house price, it will also affect loan availability and the demand for loan. If interest rate increases, consumers are less likely to demand loan, leading to a decrease in the demand for

loan. Oil prices might also be a determining factor directly or indirectly affecting homes prices and land value.

With the understanding of the complexity of house price and land value determination, the most beneficial means of addressing this problem is to first understand the complex factors affecting land prices. There are three main categorical factors affecting land value. They are science and technology, land appreciation, and general increase in prices, commonly referred to as inflation (Xiaoming Jin, 2010). Many of these factors breakdown into several other sub-factors. The progress of science and technology and the development of productivity plays a crucial role in the determination of land prices. The science and technology industry are a significant sector of the U.S. economy. This field has brought about increased level of productivity, exponential increase in efficiency in several areas of life. However, as productivity increases and growth rate of the Gross Domestic Product (GDP) might be increasing land value.

Understanding the Problem

The economy has experienced a rapid growth in recent years. Unemployment rate is at a record low of 3.7 percent (Trading Economics, 2019), productivity and efficiency in both the industrial and agricultural sector has grown faster compared to previous decades. However, many of these beneficial traits have created an increase in the value of residential land. The massive industrial improvement and growth, the increase in network speed, rise in the number of trains, aircrafts, and the highly sophisticated transport and logistics facilities now available has made the earth relatively smaller and land is thereby more costly from a lack of availability (Xiaoming Jin, 2010). This phenomenon of increased value (price) because of decreased availability is based on the theory of demand and supply. This is because a decrease in the quantity of a certain good available to consumers, in this case residential land, tends to increase the price for that good, *cetris-Paribus*.

Land value appreciation is another complex area of the real estate industry and could sometimes be difficult to quantify. Conducting appraisal of land could sometimes involve analyzing not only the directly affecting factors but also the indirect ones. This is because land is a non-renewable resource; its value generally increases with time. The decrease in quantity available also aids in increase in the rate of land value appreciation. As mentioned earlier, a decrease in quantity tends to increase prices. Although many of these direct factors are pivotal in estimating land value appreciation, several indirect factors also play a crucial role.

The geographical location of the land is extremely important in calculating the land value appreciation. For example, residential land in Lubbock, Texas would most probably not have the same price as a similar plot of land in Dallas, Texas. This phenomenon is because of several contributing factors such as road networks, restaurants, and recreational parks that are available in the area. This means that as businesses and companies move into the area it might cause the land value in that area to go up. This was experienced in 2018 when Toyota moved one of their production plants to Plano, Texas. There was also similar experience in many other cities as several businesses and companies flooded the DFW – A area.

Several factors contribute to the increase in land value. It may seem ironical, but inflation plays a vital role in land value determination. This is because as the general price level of commodities rise, the price of many non-consumer commodity like land also rise. The increase in inflation rate has a direct impact on interest rate. This is because as inflation rate rises, investors also tend to increase the required rate of return to account for inflation and ensure they have a profitable return. This increase in interest rates will have a significant impact on the demand for loans to purchase houses. Ultimately decreasing the demand of houses as a result of the increase in interest rate.

CHAPTER II

METHODS

Directed Acyclic Graphs (DAGs)

This research uses latest advances in the machine learning and artificial intelligence graphical learning techniques developed by Pearl (2009), namely Directed Acyclic Graphs (DAGs) to uncover complex causality structures among set of variables potentially determining the house value in the greater DFW – A area. The causality structure among the set of variables is uncovered using statistical package Tetrad 6.3.4 (Spirtes et al, 2000) and using the Greedy Equivalence Search (GES) (Chickering, 2002) machine-learning algorithm within Tetrad as applied in Dharmasena, et al (2016). The GES finds the optimal causal structures in order to minimize a Bayesian Information Criteria (BIC) in equivalence graphical structures. Once the graphical causal structure is developed, Structural Equation Models (SEM) are developed based on the endogeneity, exogeneity and weak exogeneity feature of variables.

This research uses the following variables: inflation, mortgage rate, population change, GDP, disposable income, house selling price. Also, we added three lag effects for each variable. This is because it is understood that sometimes a change in an independent variable of a prior period may have an effect on the dependent variable in the current period. For example, if disposable income increases in the first quarter of the year, it may not have an effect until the third or fourth quarter of selling price data. We collected quarterly data from government agencies for all the variables ranging from the fourth quarter of 2010 through third quarter of 2019.

CHAPTER III

RESULTS AND DISCUSSION

Directed acyclic graphs among the set of variables considered in the study are shown in Figure 1
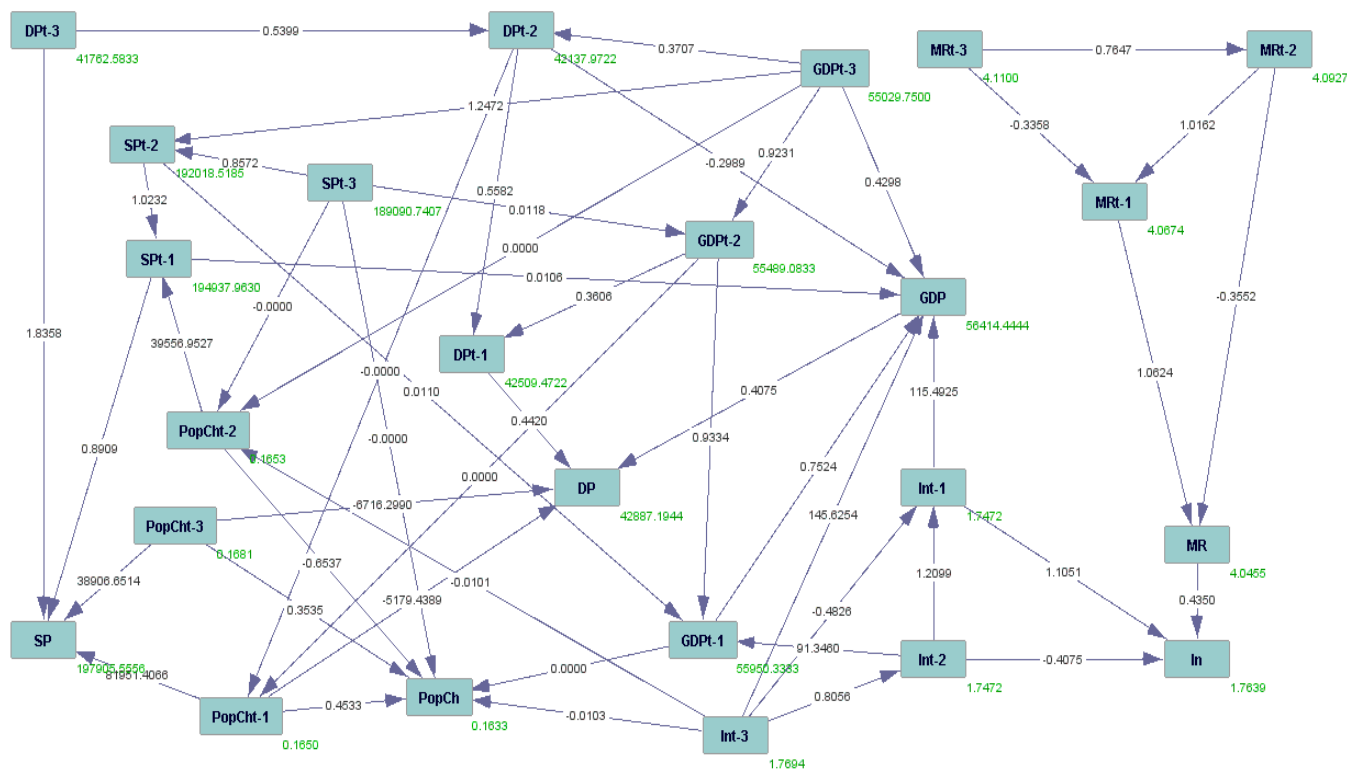

Figure 1: Directed Acyclic Graph (DAG) developed for contemporaneous and lagged variables considered in the study.

Table 1: Variables and Definitions:

Definitions	Time Lag Variables
SP = Selling price	t – 1 = lagged by 1 quarter
MR = Mortgage rate	t – 2 = lagged by 2 quarters
DP = Disposable income	t – 3 = lagged by 3 quarters
In = Inflation rate	
PopCh = Population change	
GDP = Gross Domestic Product	

According to Figure 1, home selling price (SP) in the current time (contemporaneous time) is determined directly by past period selling price (SPt-1), change in population in previous quarters (quarters and 3) (PopCht-1 and PopCht-3), and previous quarters' disposable income (3rd quarter) (DPt-3). Population change and disposable income are related directly *(PopCht-1→DP)* and indirectly *(PopCht-2→SPt-1→GDP→DP)* that have implications on the home selling price (SP) directly or indirectly. GDP affects the selling price (SP) in a causal chain relationship *(GDPt-3→SPt-2→SPt-1→SP)*. Mortgage rate (MR) and inflation (In) are related in direct causality relationship (MR→In) where past quarters' inflation rate affects the home selling price in a causal chain relationship via population change variable *(Int-3→PopCht-2→SPt-1→SP)*. Mortgage rate affects the disposable income (DP) in a back-door relationship via inflation and GDP *(MR→In←Int-2→GDPt-1→GDP→DP)* and disposable income (DP) affects the selling price (SP) in a back-door causality relationship via population change *(DP←PopCht-1→SP)*. It is evident that population change, past selling price and disposable income are directly related to home selling price in the current time. However, inflation rate, mortgage rate and GDP are related to home selling price in a complex indirect relationship.

The structural equation model developed based on direct causing factors of home selling price is as follows (based on the Figure 1).

$$SP = 1.84 * DP_{t-3} + 0.89 * SP_{t-1} + 38906.65 * PopCh_{t-3} + 81951.41 * PopCh_{t-1}$$

We did not include variables that are indirectly influencing SP since those *back-door* paths (Dharmasena and Bessler, 2018) are essentially blocked by direct causal variables.

CHAPTER IV

CONCLUSIONS

The objective of conducting this research was to understand how residential land values in the greater DFW – A area are determined and understand the complex economic variables affecting land prices. Direct factors affecting land values in the greater DFW – A area are past selling price, personal disposable income, and change in population. Other variables such as GDP, mortgage rate and inflation rate are not impacting the land values directly, however, according to the DAG developed above these variables are affecting land prices indirectly in a complex relationship. As the real estate industry continues to expand, we seek to pursue future research in understanding the relationship between the independent variables as they are related to home value (selling price) in a complex relationship.

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