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Does land price affect housing prices? Evidence from Santiago, Chile 2008–2019

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Abstract

This study embarks on an exploration of the intricate relationship between land prices and housing prices within the dynamic urban landscape of Santiago, Chile, spanning from 2008 to 2019. Amidst an escalating housing affordability crisis and the burgeoning prevalence of informal settlements, this research seeks to elucidate the underlying factors contributing to housing price dynamics, with a particular emphasis on the role of land prices. Utilizing a robust dataset encompassing over 556,400 transactions, meticulously compiled from the Santiago Real Estate Registrar, this investigation employs a rigorous multi-criteria evaluation methodology, incorporating Granger causality analysis to dissect the complex interplay between various economic indicators. At the heart of this analysis lies the innovative application of weekly data transformations and the Augmented Dicky-Fuller test to ensure the stationarity of variables, thereby laying a solid foundation for the Granger causality assessment. The study's findings illuminate a nuanced landscape where, contrary to prevailing assumptions, land prices do not exhibit a universally significant impact on housing prices. Instead, the influence of land prices on housing affordability is intricately linked to other pivotal factors, including mortgage interest rates, inflation, and market indices such as the Santiago Stock Exchange IPSA. This research not only challenges conventional wisdom regarding the primacy of land prices in housing market dynamics but also offers valuable insights into the multifaceted nature of real estate economics in Santiago. By unraveling the limited causality between land and housing prices, this study contributes a critical perspective to the ongoing discourse on urban development and housing policy in Chile. It underscores the imperative for policymakers to adopt a more holistic approach, considering a broader spectrum of economic variables in addressing the housing affordability crisis and fostering sustainable urban growth.

Highlights for public administration, management and planning:

- Land value has traditionally been considered a fundamental variable in housing prices; however, the evidence provided argues that this condition is not unequivocal.
- It is crucial for macroeconomic policymakers to consider that inflation control measures impact housing prices.
- The performance of stocks in local stock markets has a statistically significant impact on housing prices, creating room to incorporate financialization as a problem to be addressed through public policy.
- The mortgage rate is a determining factor in ensuring housing affordability, for which central banks can take measures aimed at improving housing tenure security through differentiated monetary policy options by products.

Keywords

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1 Introduction

In Chile, there has been an increase in housing prices, which has been declared unaffordable for the majority (CNN 2019; Vergara-Perucich 2021; Vergara-Perucich1 & Aguirre-Nunez 2020). This is exacerbated by the presence of a structural housing deficit, which since 1998 has remained at around

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500,000 households that still do not have access to quality housing with secure tenure (Hidalgo-Dattwyler et al. 2017; Vergara-Perucich 2021). Recently, the housing access crisis has been accompanied by a drastic increase in informal settlements in Chile's major cities (Flores 2018; TECHO 2021, 2023-03-14). According to the national survey on informal settlements conducted by the Ministry of Housing and Urbanism, many households decide to leave the formal city for economic reasons, with housing prices being the triggering factor (Flores 2016; MINVU 2020; Vergara-Perucich & Boano 2019). Regarding housing prices, specialized literature has indicated that land prices are a key factor in explaining such formation (CNDU 2015; Encinas et al. 2016; Forray & Castillo 2014; Sabatini 2000; Sabatini et al. 2017); however, the evidence used to argue this stance does not come from studies exploring causal relationships between variables. Aiming to contribute to understanding the reasons behind the increase in housing prices and to complement the literature, this study analyzes the causal relationship in the Granger sense between land prices and housing prices in Greater Santiago, where nearly half of Chile's population lives.

In the case of Chile, different efforts have been implemented to try to explain the economic rationale in the formation of housing prices. In this regard, the technique generally used to explore housing prices is based on ordinary least squares regressions with the hedonic pricing method. From its application, in 1992 it was identified that socioeconomic homogeneity and housing density in each sector are good explanatory factors for housing prices in Chile (Figueroa & Lever 1992). However, this study is based on a market study for a reality very different from the one that eventually settled in 2001, when, through the reform of the capital market, new investment actors began to participate in the production and marketing of housing, especially referring to financial institutions, insurance companies, and investment groups (Cattaneo Pineda 2011). One of the explanatory variables that recurs in different studies is the importance of land in forming housing prices, both in terms of location and the land's own price. That is, a neighborhood with good attributes and good land value can project the price of housing (Parrado et al. 2009; Quiroga 2013; Sagner 2011). The weight of land on housing prices has even been indicated in legislative projects as a key factor to help make housing more affordable (Bannen et al. 2019; MINVU 2018). Both for its price and for its location value or even for the actors participating in the land market, the literature on the case of Chile gives prominence to land price when it comes to seeking explanations for high housing prices (Aguirre Núñez et al. 2019; Bagnera 2016; CChC 2015; Correa et al. 2022; Encinas et al. 2016, 2019). Other approaches, meanwhile, focus their attention on market flaws and state omissions, leaving the production and allocation of housing to economic power, mainly occupied by actors with financial purposes (Hidalgo-Dattwyler et al. 2017; Hidalgo & Arenas 2012; Janoschka & Hidalgo 2014). These arguments align with other econometric approaches that focus on purely financial factors, associated with banking entities through interest rates or even with the participation of real estate companies in the stock market (Silva & Vio 2015; Vergara-Perucich 2022a,b). Unlike existing studies for the case of Chile, this article shares the results of a dynamic causality analysis between housing prices and land prices, adding other control and verification variables that emerge from the literature. The Granger causality study applied to the relationship between land value and real estate market in Chile has not yet been published, and therefore the results presented are of great value for a heated discussion in that nation. The main finding is that the causal relationship between land prices and housing prices is not as significant as indicated in much of the literature, which implies that new approaches should be developed to better understand the fundamentals of housing prices in Chile, including housing policies that incorporate this finding into their design.

2 Materials and methods

The source of the data is the daily transaction records identified at the Santiago Real Estate Registrar, collected by Inciti SpA. These data were acquired for this research in July 2019. In total, the analysis is based on 556,400 transactions with daily records between March 2008 and September 2019. The records show differences by address, commune, typology, buyers, sellers, and material quality of the houses when applicable. Due to the high frequency of data, it was decided to construct weekly time series with moving averages every three weeks as suggested by James Hamilton to smooth time series (Hamilton 2018). The unit of measure is the value of transactions expressed in UF/m^2. In Chile, the UF or Unidad de Fomento is an inflation-indexed unit, which allows for the comparison of values by eliminating the noise that the Consumer Price Index (CPI) might introduce in such measurements. Nonetheless, as indicated later, to achieve the stationar-

ity of the variables, some transformations are applied. In summary, time series were constructed with 470 observations each, with weekly frequency and smoothed by a three-week moving average. The descriptive statistics of the included variables can be reviewed in Table 1.

In this data source, different searches were conducted to construct the time series. First, an aggregated search was made for the entire Greater Santiago area covering prices and transactions for apartments, houses, lots, parcels, and industries. For the purposes of this study, it was crucial to have what could be interpreted as land price. Greater Santiago is a highly urbanized territory, meaning the land that real estate developers often pay for corresponds to houses and not necessarily to lots or parcels. They also acquire industries. For this reason, the data were cleaned in this order. Only properties with more than 300 m^2 of land and that were also purchased by companies were considered for evaluating the land price, as key filters. To avoid repetition of relationships and prevent collinearity, houses that were included in the land price sampling were then excluded from the house price analysis database. On the other hand, all values are expressed in UF/m^2, both for the land value and for the data related to housing transaction prices (specifically houses or apartments). The use of UF as a reference value allows the price to be comparable over time, since in Chile, the UF is an inflation-indexed monetary unit that is adjusted daily, meaning variations reflect direct price changes over time and not price-inflation.

To decide which variables to incorporate into the model, the process began with basic ones to check if the land price influences the housing price, namely, land price, house prices, and apartment prices. Then, based on a literature review, other control variables were included to test whether the housing price is more causally influenced by variables other than land price. Using daily frequency information available from the Central Bank of Chile, inflation, monetary liquidity as an indication that wages and cash flow influence housing prices, the mortgage interest rate as the primary financing mechanism for purchasing housing in Chile, and the IPSA, to review the impact of the stock market on housing prices, were added as explanatory variables. The same transformation to weekly values smoothed by a three-point moving average was applied to the daily series.

Upon an initial review of the variables (Fig. 1), it was observed that they were not stationary, leading to the application of a differencing transformation for each variable to create a time series with observations suitable for accurate analysis, which specifically requires the variables to be analyzed in their stationary form. As a result of the transformation (Fig. 2), the Augmented Dicky-Fuller test was run to check for stationarity, and the result was optimal, as indicated in Table 2.

Table 2 Augmented Dicky-Fuller Test based on Akaike criterion for stationarity test

Variable	p-value
Land value (UF/m^2)	4.914×10^{-15}
House prices (UF/m^2)	2.267×10^{-9}
Apartment prices (UF/m^2)	2.171×10^{-7}
IPSA (Blue chip index)	7.184×10^{-21}
Cash flow	0.0003532
Inflation	$4.725\ x^{-8}$
Mortgage interest rate	0.000723

With the assurance of working with stationary variables, the number of lags needed to evaluate in the Granger causality model for each variable was reviewed, according to the Akaike, Hannan-Quinn, and Schwarz criteria. Initially, 26 lags were applied as the result of the highest amount according to the Akaike criterion, however, the initial exploration of the joint model indicated that the Cash flow was not statistically significant, and then 19 lags were chosen, as indicated by the Akaike criterion for the mortgage interest rate, expressed in Table 3.

Table 3 Order selection by Akaike's Criterion (AIC), Hannan-Quinn Criterion (HQ), and Schwarz Criterion (SC)

Criterion	Land value	House prices	Dept. prices	IPSA	Inflation	Cash flow	Mortgage Int. Rate
AIC(n)	15	9	15	10	3	26	19
HQ(n)	12	7	8	9	3	20	12
SC(n)	7	7	8	8	2	13	8

With the data reviewed following the mentioned criteria, a second set of data was made, separating land and housing prices by sectors of Greater Santiago. Santiago city is highly segregated by purchasing power (Agostini et al. 2016; Borsdorf et al. 2016; Sabatini et al. 2017; Truffello & Hidalgo 2015). This observation is relevant since the city

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Table 1 Descriptive statistics

	Mean	Median	Min	Max	Std. Dev.
Land value (UF/m^2)	15.5850	13.7150	6.6626	110.4900	9.1129
House prices (UF/m^2)	28.3620	27.6290	11.9300	45.7880	5.6430
Apartment prices (UF/m^2)	71.5320	63.6220	35.1580	172.3400	25.8950
IPSA (Blue chip index)	3.6414	3.5000	1.1667	5.2500	1.0077
Cash flow	2 045 300	2 161 000	1 258 200	2 762 400	486 040
Inflation	0.0006	0.0005	−0.0366	0.0394	0.0032
Mortgage interest rate	3.8484	3.7762	2.5300	4.5409	0.4577

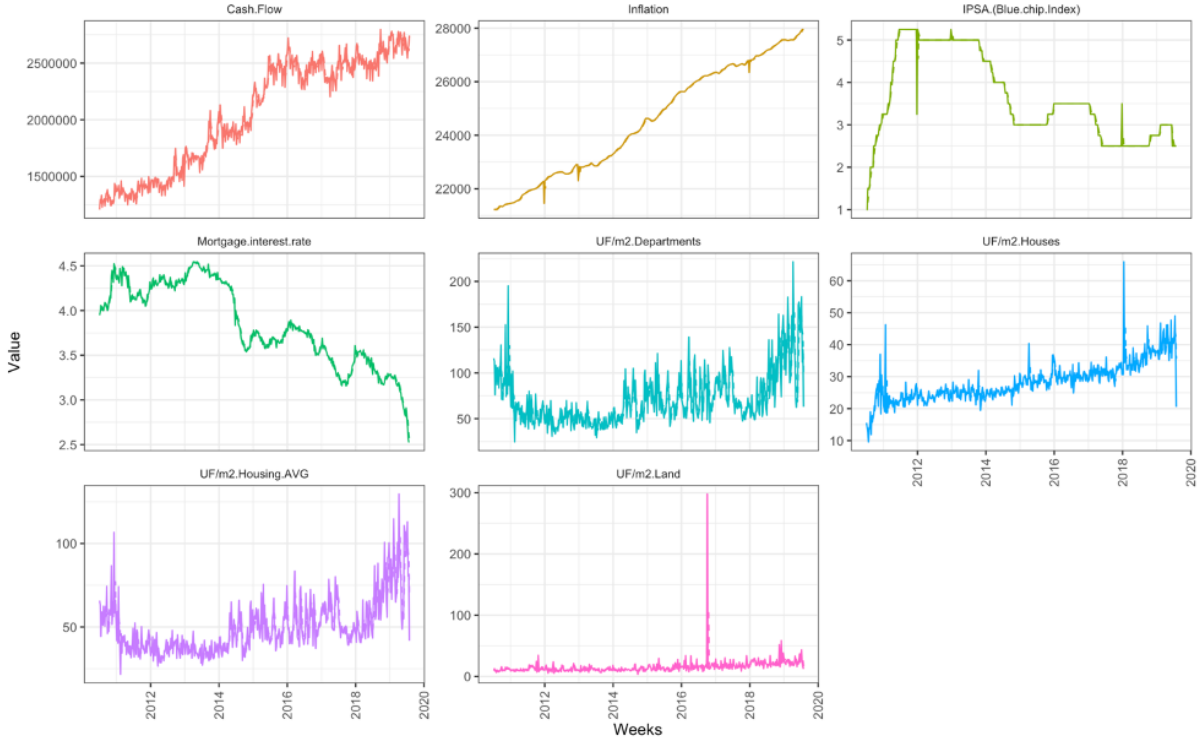

Fig. 1 Variables without transformation

can be classified according to these segregation factors. For this study, the criterion of separation is taken from the proposal by Luis Fuentes et al., who suggests the existence of a North, South, West, East, South-East, South-West, and Center-East Santiago (Fuentes et al. 2017). From the available data, a second table of land and housing price information was created with divisions for North, South, Center-East, and West. There was not enough data for South-East and South-West in this evaluation, so they were excluded. Table 4 presents the descriptive statistics for each sector.

For this statistical analysis, a Granger causality test is applied, which is a widely used strategy in econometrics to analyze dynamic relationships between variables (Altuzarra & Esteban 2011). This test empirically evaluates the behavior of one time series in relation to another time series. The mathematical definition of the Granger causality test states that a variable X is said to Granger cause another variable Y if Y can be better predicted from the past of X and Y together than from the past of Y alone (Chee-Yin & Hock-Eam 2014). In other words, if the lags of a variable Xt can predict future values of a variable Yt, while including lags of both variables, then Xt Granger causes Yt (Fernandois et al. 2020). In the results of the Granger tests, the F-statistics and p-value will be presented. To identify a causal relationship, it is required that the p-value be less than 0.05, while the F-statistics should

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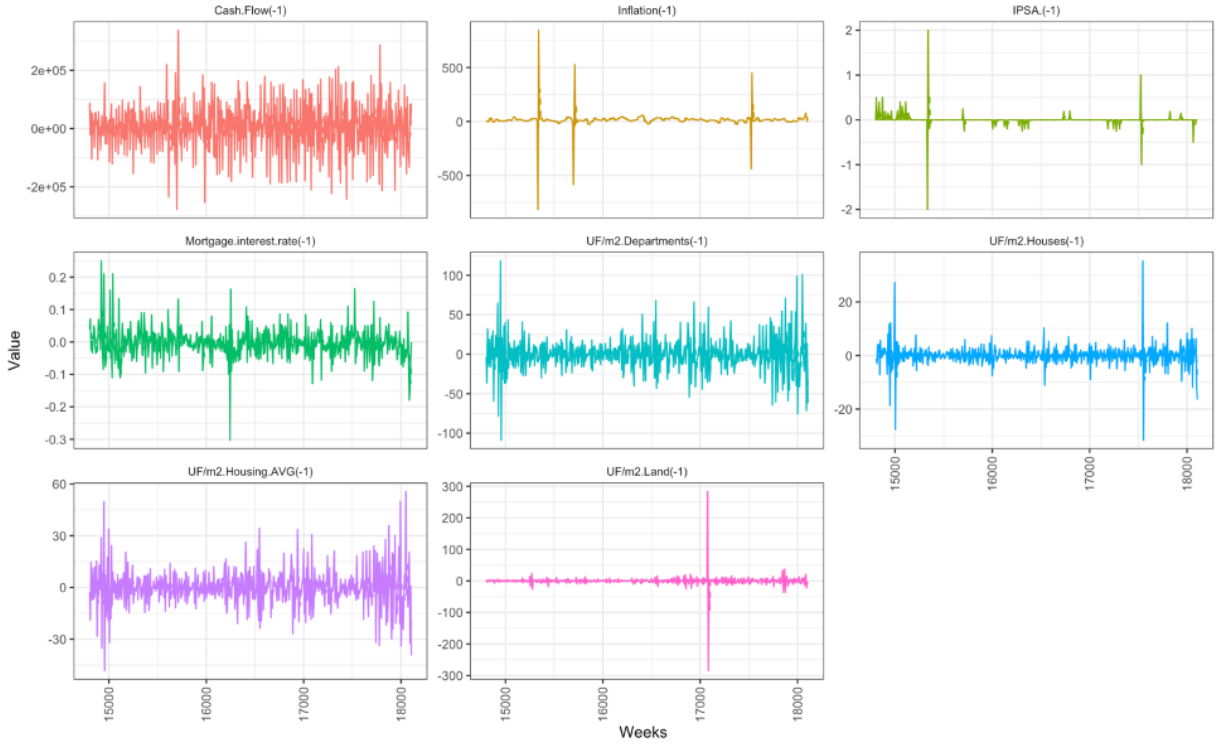

Fig. 2 Variables after transformation

be greater than the p-value. For the Granger test to be applied, two stationary time series are studied in pairs to check if the lags of one variable X can predict the time variations of the other Y. The null hypothesis states that X does not cause Y in the Granger sense.

The model was originally proposed by Clive Granger in 1969, who sought to deepen the analysis of regression that only establishes relationships with causal possibilities (Granger 1969). However, despite its name, it has been indicated that the Granger causality test is not directly a model that clearly identifies causality between two variables, but rather allows predicting the variations of one variable from the information provided by another variable (Bahmani-Oskooee & Wu 2018; Emirmahmutoglu et al. 2016; Gao et al. 2021). According to Hamilton, the Granger causality model identifies whether one variable A predicts another B, that is, whether it establishes a mechanism to verify the precedence of one variable over another (Gujarati & Porter 2009; Trapletti & Hornik 2022). For the purposes of this study, the analysis seeks to verify the potential causal relationships between housing prices and land prices, as has been proposed in the literature on the case of Chile. Additionally, to add richness to the study, other variables are evaluated to explain housing prices, to identify whether land price is comparatively more important than other variables in relation to projecting variations on housing prices.

As a summary, this research embarked on an in-depth exploration of the real estate dynamics in Greater Santiago, leveraging transaction records from the Santiago Real Estate Registrar. The primary objective was to discern the intricate relationship between land prices and housing prices, accounting for the influence of key economic indicators such as inflation, monetary liquidity, mortgage interest rates, and stock market performance. The methodological approach involved constructing weekly time series from the raw daily transaction data, employing a three-week moving average to smooth out fluctuations. These time series were then meticulously transformed to ensure stationarity, a prerequisite for accurate analysis. The core of the statistical analysis was the Granger causality test, employed to investigate potential cause-and-effect relationships between housing prices and land prices, as well as other control variables. The analysis also delved into the spatial dimension, examining these relationships across different sectors of Greater Santiago, acknowledging the city's socio-economic segregation. In essence, this study

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Table 4 Descriptive statistics of land price and housing price for each sub-sector of Greater Santiago

		Mean	Median	Min	Max	Std. Dev.
Centre-east	Land value	26.34	22.99	8.25	211.97	17.54
	Housing prices	39.66	39.04	26.29	57.72	7.13
North	Land value	8.97	7.61	2.61	46.99	5.88
	Housing prices	28.68	27.29	19.63	47.97	4.63
West	Land value	7.65	6.74	2.31	42.63	4.05
	Housing prices	28.97	28.32	18.74	47.89	5.77
South	Land value	9.56	8.15	3.10	30.74	4.41
	Housing prices	31.61	30.45	21.57	45.22	5.67

Table 5 Granger causality between land price, house price, and apartment price

Null Hypothesis	Observations	F-Statistic	Probability	Lag(s)
Apartment price (-1) does not Granger cause House price (-1)	454	1.87	0.0189	17
Apartment price (-1) does not Granger cause House price (-1)	456	1.84	0.0275	15
Apartment price (-1) does not Granger cause House price (-1)	455	1.72	0.0409	16
Land price (-1) does not Granger cause Apartment price (-1)	465	2.25	0.0373	6
Land price (-1) does not Granger cause Apartment price (-1)	467	2.42	0.0475	4

sought to provide a comprehensive understanding of the factors driving housing prices in Greater Santiago, with a particular focus on the role of land prices.

3 Results

To organize the Granger causality tests, two approaches were taken: one separating relevant urban zones (center-east, north, south, west) and another distinguishing between types of housing units, such as houses and apartments. While the first strategy aimed to determine if the causal relationship between land price and housing price varies depending on the city sector, the second strategy sought to evaluate the causality between house or apartment prices and to compare these causal influences with other variables that literature has indicated as relevant for defining housing prices in Chile.

When examining causal relationships considering only housing and land prices with 19 lags, very specific causal relationships are observed in relation to the other variables in the study. Table 5 indicates only the Granger causality relationships between land prices, house prices, and apartment prices. Among the main findings, there is no sustained causal relationship between land price and house price in time. However, a causal relationship does appear between land price and apartment prices for lags of 6 and 4 weeks with statistical significance just above 5%. On the other hand, there is a causal relationship from apartment prices to house prices. This initial finding indicates the need to further complexify the analysis of the possible causal relationship between land price and housing price, which would only apply to a specific type of housing (apartments) in two lags, one at 6 weeks and another at 4 weeks.

Table 6 presents the results of the pairwise causality test between land prices, house prices, and apartment prices, adding possible explanatory variables in this analysis such as the relationship with mortgage interest rates, inflation, and the IPSA from the Santiago Stock Exchange. From this analysis, isolating only the factors that present a Granger causality relationship with housing prices, among the explored variables, only houses show causal influence from inflation, mortgage rates, and IPSA for the 19 lags studied. These results are striking and certainly call into question part of the literature that attributes a leading value to land price in explaining the formation of housing prices.

Santiago is a highly segregated city, with clear socio-spatial differences between districts (Correa et al. 2022, 2023; Ulloa-Leon et al. 2023). As part of this exploration, it was examined whether separating the city by socioeconomically homogeneous zones could affect the causal relationships. The results of this exercise are presented in Table 7, where it is checked whether the land price has causal re-

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Table 6 Granger causality between land price, house price, and apartment price

Null hypothesis:	Obs	F-Stat.	p-value	Lag
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	468	5.8278	0.0006	3
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	467	4.7825	0.0009	4
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	469	6.8071	0.0012	2
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	466	3.9661	0.0016	5
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	465	3.3571	0.0030	6
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	464	3.1006	0.0033	7
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	463	2.7511	0.0057	8
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	462	2.5146	0.0081	9
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	461	2.2628	0.0138	10
Inflation (-1) does not cause in the sense of Granger at the price of houses (-1)	460	2.0847	0.0203	11
IPSA (-2) does not cause in the sense of Granger at the price of houses (-1)	465	3.9295	0.0017	5
IPSA (-2) does not cause in the sense of Granger at the price of houses (-1)	468	6.3416	0.0019	2
IPSA (-2) does not cause in the sense of Granger at the price of houses (-1)	466	4.2749	0.0021	4
IPSA (-2) does not cause in the sense of Granger at the price of houses (-1)	467	4.8535	0.0025	3
IPSA (-2) does not cause in the sense of Granger at the price of houses (-1)	464	3.3746	0.0029	6
IPSA (-2) does not cause in the sense of Granger at the price of houses (-1)	463	2.8454	0.0065	7
IPSA (-2) does not cause in the sense of Granger at the price of houses (-1)	462	2.5099	0.0112	8
IPSA (-2) does not cause in the sense of Granger at the price of houses (-1)	461	2.2249	0.0196	9
IPSA (-2) does not cause in the sense of Granger at the price of houses (-1)	458	2.0056	0.0224	12
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	458	2.6612	0.0019	12
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	459	2.7035	0.0022	11
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	457	2.5161	0.0025	13
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	465	3.6892	0.0028	5
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	464	3.1671	0.0047	6
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	463	2.9257	0.0053	7
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	467	4.2743	0.0054	3
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	455	2.1813	0.0064	15
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	456	2.1634	0.0085	14
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	454	2.0789	0.0085	16
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	453	2.0371	0.0087	17
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	462	2.5857	0.0091	8
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	461	2.4755	0.0092	9
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	460	2.2272	0.0155	10
Mortgage Rate (-2) does not cause in the sense of Granger at the price of houses (-1)	466	2.8957	0.0218	4

Table 7 Granger causality test to verify if the land price by each sector of Greater Santiago impacts the housing price

Null Hypothesis	Obs.	p-value	Lag
West Land Price does not Granger cause West Housing Price	469	0.0423	1
Center-East Land Price does not Granger cause South Housing Price	469	0.0492	1
South Land Price does not Granger cause West Housing Price	469	0.0164	1

lationships on the housing price in each of the reviewed sectors. Again, the result for 19 lags per pair is much scarcer than expected. The impact of land price variation on housing price only occurs in the first lag. The housing price in the western zone of the city has a significant causal relationship at the first lag with the housing price in the west as well. It is noteworthy that other results cross zones of Greater Santiago: the housing price in the center-east has a causal relationship with housing on the south side, while the land price on the south side has a causal relationship with the housing price on the west side.

Circulating money was not statistically significant in explaining causal relationships with the housing price or land price, leaving the main explanatory

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Table 8 Summary of results of the research

Variable	Lag (Weeks)	p-value	Type of Housing	Sector
Land Price - Apartment Price	4	0.0373	Apartments	General: Greater Santiago
	6	0.0475		
	15	0.0189		
Apartment Price - House Price	16	0.0275	Houses	General: Greater Santiago
	17	0.0409		
Inflation - House Price	2,11	0.05	Houses	General: Greater Santiago
IPSA - House Price	2 to 11	0.05	Houses	General: Greater Santiago
Mortgage Rate - House Price	3 to 17	0.05	Houses	General: Greater Santiago
West Land Price - West Housing Price	1	0.0423	Houses	Specific: Western Santiago
Center-East Land Price - South Housing Price	1	0.0492	Houses	Specific: Central and Southern Santiago
South Land Price - West Housing Price	1	0.0164	Houses	Specific: Southern and Western Santiago

variables as the mortgage interest rate, inflation, and IPSA for the price of houses, while for apartments, their price is causally influenced by the land price for two lags, as previously indicated. Table 8 is a summary of the main findings of this study.

The summarized results table highlights the main findings from the Granger causality tests applied in the study. The results reveal specific causal relationships between land prices, housing prices, and other economic variables across different housing types and sectors within Greater Santiago. Notably, land prices significantly influence apartment prices, but not so frequently in relation to house prices directly. However, apartment prices do Granger cause house prices, indicating a complex interplay between different housing market segments. Moreover, inflation, stock market performance (IPSA), and mortgage rates exhibit strong causal relationships with house prices, underscoring the importance of financial factors in housing market dynamics. Spatially, the study found that the causal impact of land prices on housing prices is sector-specific, with significant relationships identified within the western, central-eastern, and southern parts of Santiago. These findings emphasize the multifaceted nature of housing price formation, suggesting that both economic and spatial factors must be considered in urban housing policy.

4 Discusion

Different literature contributions had posit that land price is perhaps the main factor defining housing prices in different contexts (Altuzarra & Esteban 2011; Braakmann & McDonald 2020; Deng & Ma 2007). In the case of Chile, a national urban policy of social integration was recently approved in Congress, centering its action strategies on the management of urban land as a mechanism to ensure universal access to housing. While this measure may yield optimal results, in its argument submitted to Congress on December 5, 2018, it stated that in city sectors with adequate standards of quality of life and urban development, the value of land prevents the establishment of affordable housing for the majority, a point that is debatable based on the results of this study, where the housing price, understood in Chile as the main element conditioning secure access to housing, does not show a direct causal relationship with land value. This had been previously indicated in a study by Vergara and Aguirre, who presented evidence on the significant difference between housing production costs and real estate project profits, indicating that although the land value paid was a factor, the profits on investment were higher than this value (Vergara-Perucich1 & Aguirre-Nunez 2020). The results presented in this article indicate that while there is a causal relationship between housing price and land price for apartments in Greater Santiago, this relationship is much weaker than other factors such as mortgage interest rates, IPSA, or even inflation.

Among the causal relationships of land price on housing price, only a statistically significant relationship on the price of apartments is observed. The interpretation of this result is that there is an effect of land on housing price when the purchased land is useful for generating processes of verticalization and densification in key urban areas. That is, the real estate market depends on land value to extract rent from the economy of scale that high-rise construction allows compared to horizontal construction. While a reference cost of high-rise housing construction in Santiago is 14 UF/m^2, the same value for horizontal housing is close to 25 UF/m^2. Thus, while the average price of high-rise housing

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is 71.53 and for houses is 28.36, profitability lies in making the most of the land that allows for high-rise construction, where each square meter sold yields a much better investment return than horizontal construction, allowing the company to assume the risk of purchasing higher-value land.

A significant finding of this research is that the land price in the western sector of the city has a causal influence on the housing price within the same zone for the first lag. This means that the land price in communes such as Pudahuel, Estación Central, Quinta Normal, or Maipú does have a causal relationship with the housing price. These communes have seen significant real estate development in recent years. Other causal relationships indicate that the land price in the Center-East sector impacts the housing price in the South sector, while the same occurs with the land price in the South sector impacting the housing price in the West sector. This may indicate that homebuyers move from communes with high land prices to communes where the average housing value is lower (Vergara-Perucich 2022a; Vergara-Perucich et al. 2023). According to descriptive statistics, the average housing value in the Center-East is 39.66 UF/m^2, in the South is 31.61 UF/m^2, and in the West is 28.97 UF/m^2, in a relationship that moves from the highest land value in the Center-East to the lowest value in the West. While this is a valuable observation, further analysis is needed to assert that there is a circulation of households and investors in this sense, seeking lower land and housing values.

A valuable finding is that financial variables such as IPSA or the mortgage rate have significant causal relationships with house prices. This could lead to a more in-depth analysis of financialization processes as causes of rising housing prices. The literature mentions the importance of financialization on access to secure housing tenure (Aalbers 2017; Hidalgo Dattwyler et al. 2019; Rolnik 2012, 2013) and is a factor scarcely explored from the quantitative perspective with econometric techniques on causal relationships. Initially, this finding allows for a deepening of these approaches.

It is notable that circulating money is not a cause of housing prices or land prices. This could open a new line of interpretation from the fact that in the case of Chile, apparently, housing is no longer purchased with money but almost exclusively with debt instruments, which would make sense with the significant causal relationship revealed between house prices and mortgage rates.

This research offers substantial contributions to the theory of real estate development in Chile, particularly by challenging the long-standing assumption that land prices are the primary determinant of housing prices. This finding has the potential to initiate a paradigm shift in how we understand the forces shaping housing markets. Traditionally, land-value theory has dominated discussions in real estate economics, positioning land prices as the central factor in housing price formation. However, this study reveals that land prices may not play as significant a role as previously thought, opening the door for further investigation into other economic variables. This critical challenge to established theory encourages a more nuanced understanding of housing market dynamics, inviting researchers to explore the roles of financialization, macroeconomic policies, and socio-spatial factors.

The study's emphasis on the role of financialization in housing markets marks another significant theoretical advancement. By empirically demonstrating the impact of financial variables, such as mortgage rates and stock market performance, on housing prices, this research aligns with and bolsters the growing discourse on housing as a financial asset. This perspective is increasingly relevant in global debates, where housing is often seen less as a basic need and more as an investment vehicle. The study's findings suggest that any comprehensive theory of real estate development must account for the broader financial context, particularly in understanding the challenges of housing affordability and the implications of treating housing primarily as a financial asset.

Moreover, the study's analysis of spatial heterogeneity across different sectors within Santiago provides a vital contribution to real estate theory by highlighting the importance of local context in price determination. Housing market dynamics are often oversimplified in generalized models that fail to account for variability across neighborhoods and regions. This research underscores the need for more refined theoretical models that incorporate local factors, such as neighborhood characteristics and patterns of socio-spatial segregation. The inclusion of these complex variables may pave the way for more comprehensive policy interventions tailored to the specificities of different urban areas. In this perspective, the use of big data may become a necessary consideration for future studies in this field.

In advocating for a holistic approach to housing policy, the study synthesizes its various contributions into a broader call for integrated policymaking. The findings suggest that focusing solely on land prices is inadequate and that a comprehensive ap-

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proach that considers a range of economic, social, and spatial factors is essential. This holistic perspective is valuable as it encourages cross-disciplinary research, bridging gaps between urban planning, sociology, and finance, and pushing for policies that are better aligned with the complex realities of housing markets.

Additionally, while the study is centered on Santiago, Chile, its findings have broader implications that could resonate globally. Drawing parallels with similar dynamics in other cities could enhance the theoretical contributions of this research, encouraging comparative studies and the development of more universally applicable theories. This global contextualization would not only broaden the impact of the study but also contribute to a deeper understanding of how various global and local factors interact in different contexts.

5 Conclusions

This article has examined the causal relationships between land prices and housing prices in Greater Santiago, applying a Granger causality test on weekly time series from 2008 to 2019. It has been determined that the causal relationship between land and housing prices is not as significant as other explored variables, such as mortgage rates or the IPSA. This finding is valuable, as such a study had not been conducted in Chile before, and decision-makers had been attributing more weight to the relationship between housing prices and land prices than it has. On the contrary, the results compel these decision-makers to explore other causal relationships, such as financial ones, to improve the understanding of the high housing prices in Chile.

Given the findings of this study, it is evident that the current regulatory approach, which focuses primarily on the management of urban land through social integration policies, is insufficient to address the complexities of housing affordability in Chile. The government could have an active role to be more effective by broadening its focus beyond land regulation to address key financial variables that significantly influence housing prices. Specifically, policies should be developed to complexify how mortgage interest rates are regulated and thus control housing price inflation, as these factors have been shown to have a more substantial impact on housing costs than land prices alone. Additionally, the government should consider the role of the Santiago Stock Exchange (IPSA) in housing price dynamics, which suggests that financial markets play a critical role in real estate affordability. By incorporating these economic factors into a more comprehensive housing policy, the government can create a more effective framework for stabilizing property prices and improving housing affordability. Nevertheless, the question on how to reduce housing prices remains open to contributions.

Furthermore, it seems pertinent to suggest that research should advance towards the study of causal relationships that can be identified at a spatial level. That is, combining Granger causality models, VAR with geostatistical techniques such as GWR or spatial structural equations, among other alternatives. In this type of analysis, the city as a complex and dynamic entity can contribute other explanatory factors that help to enhance the analysis presented here.

These results fuel the discussion on the importance of regulating the land market without examining the fundamentals of housing prices. This discussion has been part of the public agenda in Chile in recent years; however, causality or predictive studies on the matter are not abundant and certainly are not even cited by decision-makers when formulating public policies. This disconnection between evidence and public policy can lead to mistakes that will take years to correct. While this article does not claim to present absolute truths or propose a general theory, the considerations that can arise from these results deserve to be part of the discussions on the housing access crisis that Chile is experiencing.

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