



Testing Housing Price Drivers in Santiago de Chile: A Hedonic Price Approach

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Abstract: Hedonic modelling is an empirical analysis technique that is widely used to review the housing market and unpack the main determinants of price. A correct determination of housing price drivers allows a weighted prediction of the value of each dwelling for sale or rent. This paper reviews the fundamental determinants of housing prices that have been published in the literature to see which ones have a better predictive fit for the case of the housing market in the city of Santiago, Chile. From a record of 456,000 property transactions, a dataset composed of 11 explanatory variables is elaborated. Through a semi-logarithmic regression, 4 variables that contribute to explaining the formation of housing prices in Santiago, Chile, are identified. The results indicate that the socioeconomic characterisation of urban areas where housing is traded, the price of copper on the London Metal Exchange, the mortgage interest rate, the age of residential buildings are the main drivers for the main drivers of prices in Santiago. Given the crisis of access to housing in Chile, the article provides relevant information for decision-makers in housing policy.

Keywords: hedonic economics; housing in developing countries; urban policy and planning; land markets and housing policy.



Introduction

In the disciplinary field of urban economics, the study of property prices is essential to uncover the primary factors that drive value formation (Evans 1985). Emphasising exchange value and housing markets, one widely accepted idea is that population growth typically influences price formation based on existing demand, which reaches equilibrium according to households' purchasing power (Taltavull de La Paz 2003). Similar to other economic domains, prices are determined by the equilibrium between supply and demand (Krugman et al. 2013). In spatial econometrics studies applied to the property market, there is a direct relationship between a house's commercial value, its location in the city, and its specific internal attributes (Fujita et al., 2000). Rosen (1974) proposed using hedonic coefficients as a means to understand price formation. These coefficients help identify the marginal willingness to pay for a specific good under the assumption that the market is in equilibrium.

This idea aligns with the argument put forth by Case and Shiller (1990) that housing prices exhibit a spatial autocorrelation with the specific characteristics of the neighbourhoods in which they are located. In other words, a property's price is not solely determined by its internal attributes, but the city itself plays a role in shaping its value. Since the city is a collectively produced space (Lefebvre 1991), Case and Shiller's finding implies that housing prices should consider the community's ability to pay, given that public space attributes generate solidarity revenues that increase the value of the private property (Smolka and Furtado 2001; Vergara-Perucich and Aguirre-Núñez 2020a). Understanding the origin of housing prices has significant implications for ensuring access to basic goods and services, such as housing, and is therefore crucial for policymakers and urban developers competing in the housing market. The hedonic approach, as a widely used method, allows for testing the influence of various variables on price configuration. Recent evidence from China suggests that the issuance of currency by the Central Bank could influence housing price formation (Wang et al. 2020; Zhang et al. 2012). This indicates that with the increased involvement of the financial world in the housing market, prices may adjust based on growth expectations rather than the intrinsic value of housing fundamentals (Cohen et al. 2016; Cohen and Zabel 2020). A significant issue arising from the financialisation of housing is that price negotiation no longer occurs between the client and producer but between clients and intermediaries, who lack the financial power to challenge prices. According to Fernandez and Aalbers (2016), understanding the financial performance of the stock market is crucial for comprehending current housing prices, which they refer to as the financialisation of housing.

In the case of Chile, hedonic models have been employed to examine the influence of variables on housing market formation. Regarding urban aspects, Eugenio Figueroa and George Lever (1992) found that housing prices are significantly influenced by the property's size, the availability of essential urban functions in the vicinity, the socioeconomic homogeneity of the housing sector, and the population density within a block. Bernardo Quiroga (2013) adds that the number of homeowners living in the same neighbourhood is a good predictor of housing prices, highlighting the importance of security of tenure for the economy. Andrés Sagner (2009) identifies specific housing characteristics that affect prices, such as construction age and surface area. Victor Iturra and Dusan Paredes (2014) highlight the number of rooms, overall housing quality, surface area, and socioeconomic characteristics of the occupants as key factors among architectural influences on housing prices. Economic factors contributing to price formation, as identified by Eric Parrado, Paulo Cox, and Marcelo Fuenzalida (2009), include the volume of housing sales in the neighbourhood and household income. Additionally, Carmen Silva and



Camilo Vio (2015) emphasise the significance of construction material prices. From an economic perspective, both Parrado et al. (2009) and Silva and Vio (2015) find that mortgage interest rates are significant factors. Encinas, Truffello, Aguirre, and Hidalgo (2019) argue that the monopolistic condition of land is a fundamental element in understanding how housing prices are shaped. In the specific case of Chile, Idrovo-Aguirre and Contreras-Reyes (2021) suggest that since copper is Chile's main export factor, its price may impact housing productivity and, consequently, prices.

The real estate market in Chile is particularly interesting because of the implementation of the National Policy of Urban Development in 1979, which led to private investment-driven urban planning (Gross 1990). These specific conditions of the housing market make the regulations imposed by the State have a low influence on the dynamics of the real estate market. (Vergara-Perucich and Aguirre-Nuñez 2020b), allowing supply and demand to operate more fluidly than in other cases.

Table 1: Synthesis of the main findings on housing price fundamentals by hedonic analysis in the literature

Variable	Category	Source
Location	Microeconomics	Case and Shiller 1990; Encinas et al. 2019
Currency	Macroeconomic	Wang et al. 2020; Zhang et al. 2012
Size of property	Microeconomics	Figuroa and Lever 1992
Ownership	Microeconomics	Quiroga 2013
Age of construction	Microeconomics	Sagner 2009
Size	Microeconomics	Iturra and Paredes 2014
Socioeconomic features of occupants	Microeconomics	Iturra and Paredes 2014
Sales	Microeconomics	Parrado et al. 2009
Construction costs	Microeconomics	Silva and Vio 2015
Mortgage interest rate	Macroeconomics	Silva and Vio 2015
Exportation prices of the country	Macroeconomics	Idrovo-Aguirre and Contreras-Reyes 2021
Financial performance of the stock market	Macroeconomics	Fernandez and Aalbers 2016

Source: Author.

In general, the literature on hedonic pricing primarily focuses on microeconomic factors. However, the role of housing has undergone a significant transformation in the past 20 years, shifting from being a private space for family development to becoming an investment vehicle for generating rental income on invested capital. In this new context, analysing house prices solely based on microeconomic variables is inadequate. Nowadays, housing plays a crucial macroeconomic role and presents a political economy problem (Table 1). This research utilises data from the Chilean housing market to provide evidence of the substantial influence that macroeconomic variables have on the process of housing price formation. The novelty of these results allows us to comprehend the potential impact of the housing price formation process on economies, considering that housing represents a long-term financial asset.



To position the specific contribution of this article within the international discourse, a bibliometric analysis was conducted, reviewing 779 scientific articles to identify the main trends in hedonic house price research from 2019 to 2023. Thematic analysis, based on trigrams extracted from the abstracts, revealed that publications on hedonic pricing primarily focus on two main orientations: (i) methodological discussions and (ii) considerations of the localisation of housing as a predominant factor in understanding price formation. A review of the main keywords employed revealed a scarcity of macroeconomic analysis concerning house price formation, with a preference for microeconomic analysis in explaining price formation. Additionally, the relationship between prices and urban transportation is considered relevant. On one hand, articles utilising hedonic price analysis aim to discuss or define the fundamental principles of pricing, while on the other hand, articles seek to understand how prices are influenced by the location and centrality of the housing units under analysis.

The results of this study identify the statistical influence of the analysed variables on housing price formation in the Chilean case using hedonic price analysis (Micallef et al. 2021). This will enable a review of which set of variables used in the literature best contributes to explaining housing prices in the city of Santiago de Chile and other cities in South America. The analytical method employed comprises a hedonic analysis based on a semi-logarithmic regression, with the natural logarithm of housing prices as the dependent variable and the variables indicated in the literature as independent variables. The data utilised range from May 2008 to October 2018, with monthly frequency and treated based on exponential smoothing techniques. The results indicate that the socioeconomic characteristics of urban areas where housing is traded, the price of copper in the London Metal Exchange, the mortgage interest rate, and the age of residential buildings are the primary drivers in the case under investigation. Thus, macroeconomic factors exhibit statistical significance in understanding housing prices.

Materials and Methods

This is an inductive research study that employs an empirical exploration using official sources to conduct a quantitative analysis based on aggregated datasets. The analysis aims to contribute to the understanding of the drivers of housing prices in Chile by examining the fundamental factors influencing price formation, which have been widely discussed in the literature. The variables considered in the literature on hedonic pricing, including microeconomic and macroeconomic factors, are summarised in Table 1. Table 2 reviews the variables incorporated into the model of this study, selected from those indicated in Table 1, in order to empirically assess the comparative weight of these variables in the case of Chile. The objective is to determine which group of factors, either macroeconomic or microeconomic, carries greater statistical significance in influencing the price of housing in Chile.



Table 2: Variables and their descriptive statistics

Type	Variable	Unit	Description	Source
Y	Housing prices per square metre	Logarithmic transformation of USD/square metre	The average value of square metres in houses and flats sales is officially recorded in the Real Estate Register Service of Santiago. This is the dependent variable.	www.inciti.com
C	Dwellings in average square metres	Square metres	Average dimensions of the dwelling units measured in square metres. This variable is included as referred to by Figueroa and Lever (1992) and Sagner (2009).	www.inciti.com
C	Age of housing units	Year from its construction to its sale	The average age of the building where the housing units are located. This variable is included as suggested by Sagner (2009).	www.inciti.com
E	Construction cost index	Index (05 / 2008 = 100)	Index of construction costs elaborated by the Chilean Chamber of Builders. This variable is included based on Silva and Vio (2015).	www.cchc.cl
E	Wages	Index (05 / 2008 = 100)	Average wages historical record elaborated by the Central Bank. This variable is included based on Iturra and Paredes (2014), Parrado et al. (2009), and Vergara-Perucich (2021).	https://si3.bcentral.cl/
E	Mortgage interest rates	Percentage	Average interest rate issued by financial institutions.	https://si3.bcentral.cl/
E	Copper price on the London Metal Exchange	Logarithmic transformation of USD/per pound	The average price of copper pounds on the London Metal Exchange. This variable is included based on the article by Idrovo-Aguirre and Contreras-Reyes (2021).	https://si3.bcentral.cl/
E	Blue-chip index (IPSA)	Percentage	The average performance of the blue-chip index at the Santiago Stock Exchange. This variable is included based on the articles of Cohen and Zabler (2020) and the reflections of Fernandez and Aalbers (2016).	https://si3.bcentral.cl/
E	Money supply	Logarithmic transformation of Chilean pesos	Circulation of money measured in millions of pesos monthly based on the issuing of the Chilean Central Bank. This variable was included after the reflections of Zhang et al. (2012), Su et al. (2019) and Wang et al. (2020).	https://si3.bcentral.cl/
U	Land price per square metre	Logarithmic transformation of USD / square metre	The average value of square metres in land transactions is officially recorded in the Real Estate Register Service of Santiago. This variable was included based on Encinas et al. (2019).	www.inciti.com



Type	Variable	Unit	Description	Source
U	Socioeconomic development index (IDSE)	Score from 0 = low socioeconomic level, to 1=high socioeconomic level	The average score of social development at each area where transactions occurred is based on a multidimensional measurement including incomes, poverty, education level, and housing quality. This variable was included based on Figueroa and Lever (1992), Parrado et al. (2009), Quiroga (2013), Iturra and Paredes (2014), and Vergara-Perucich (2021).	Ministerio de Desarrollo Social (Social Development Ministry)
U	Housing sales	Quantity	The number of houses and flats sold in each period. This variable was included based on Parrado et al. (2009).	www.inciti.com
U	Population	Population	Population estimations elaborated by the National Statistics Institute. This variable was included based on Figueroa and Lever (1992).	www.ine.cl

Source: Author.

Gujarati (2022) suggests applying a logarithmic transformation to monetary values in multiple linear regressions to reduce both skewness and heteroscedasticity. In this set of data used for the regressions, each value transformed by taking the natural logarithm (Ln) is indicated in Table 1. Based on the evidence reviewed in the literature, the variables are classified as shown in Table 1 and categorised into the internal characteristics of dwellings (C), location aspects (U), and economic factors (E), which form groups of vectors expressed as follows:

$$C = (C1, C2, \dots, Cn)$$

$$U = (U1, U2, \dots, Un)$$

$$E = (E1, E2, \dots, En)$$

Based on the arguments presented in the literature and the model of Rodriguez Marin et al. (2017), it is expected that the price of housing will respond to the hedonic function indicated below:

$$P = p(C, U, E)$$

The hedonic price analysis technique applies ordinary least squares to the natural logarithm of housing prices as the dependent variable, considering other independent variables of an urbanistic and macroeconomic nature. This approach allows for a semi-logarithmic estimation (Voltes-Dorta and Sánchez-Medina 2020). The formula is developed as follows:

$$\ln(p) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_i X_i + \epsilon_i$$

The model utilises a collection of monthly data from 2008 to October 2018. This timeframe was selected to capture potential variations resulting from the subprime crisis in the housing market, although Chile's market was relatively unaffected by the global crisis (Valdivia and Perez 2013). Additionally, the series is truncated in 2018, prior to the onset of the social revolt in Chile (Mayol 2019; Arias-Loyola 2021). The economic impact of this revolt on the housing market remains unknown. It is worth emphasising that this study aims to examine the influence



of various variables on housing prices in Greater Santiago, rather than focusing solely on the predictive capabilities of the hedonic price model.

Results

During the period under investigation, a total of 456,133 official transactions were analysed. Among these transactions, 44.5% were related to house transactions, 47% were apartment transactions, and 1.5% were land transactions. It is important to note that a significant number of the houses transacted were likely demolished to make way for future development.

Table 3 provides a comprehensive summary of descriptive statistics for each variable. The average price per square metre of housing during the study period was found to be USD 1,882, while the price of land was USD 369. Additionally, Table 2 illustrates that the average size of a housing unit was 115.92 m². This figure may seem high, but it is important to consider that the value is influenced by the initial phase of the analysis, during which the production of houses closely matched the sale of apartments.

Overall, the data highlight the diverse nature of the transactions and shed light on the prices and sizes associated with different types of properties.

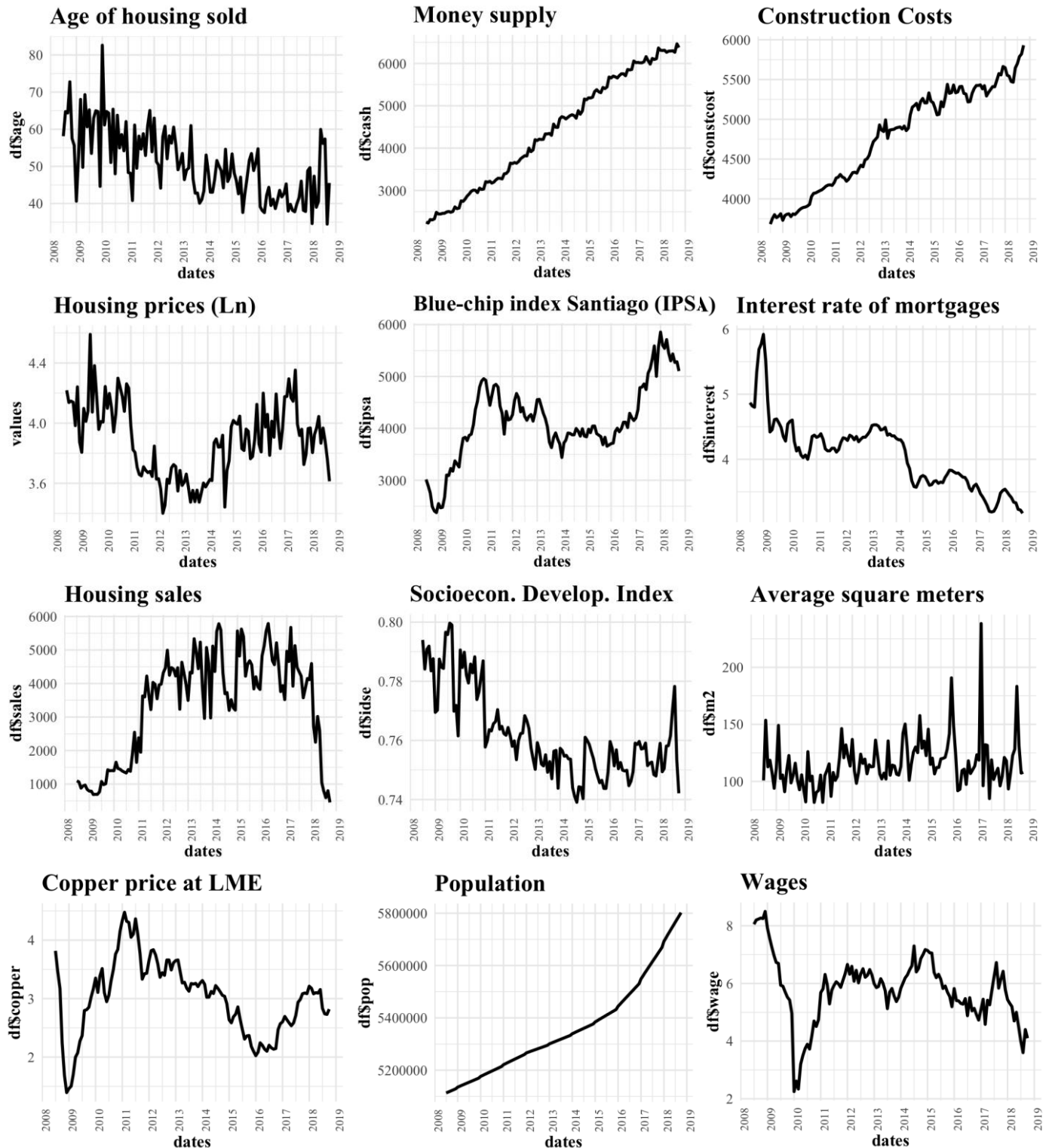
Table 3: Descriptive statistics of the variables studied

Variables	Mean	Median	Std. dev.	Skewness	Kurtosis
Ln housing prices	3.887	3.895	0.240	0.143	-0.559
IDSE	0.762	0.758	0.015	0.863	-0.170
m ²	115.920	112.740	21.271	2.186	8.970
Sales	3366.100	3873.000	1582.300	-0.444	-1.148
Age of residential building	50.710	49.540	9.270	0.519	-0.081
Construction cost index	4779.800	4889.900	632.100	-0.243	-1.313
Wage index	5.779	5.846	1.152	-0.406	1.076
Population	5361100	5322700	179700	0.756	-0.288
Mortgage interest rate	4.071	4.140	0.545	0.720	1.069
Ln land price	2.270	2.243	0.174	0.457	0.415
Ln copper price on the London Metal Exchange	1.077	1.128	0.233	-0.807	0.717
Ln money supply	8.338	8.393	0.325	-0.360	-1.192
Blue-chip index (IPSA)	4135.100	4055.500	745.030	-0.092	0.128

Source: Author based on sources indicated in Table 1 and Table 2.

Most of the values of skewness and kurtosis fall within the range of 2 and -2 (George and Mallery 2010). Among the values analysed, only the average square metre of a property (m²) exhibits high kurtosis, while most other variables demonstrate normality. Figure 1 displays the plots of the transformed data. The variables population, construction costs, and money supply exhibit a distinct deterministic trend, which was excluded from the regression model using the stepwise technique owing to the potential presence of a spurious relationship with the dependent variable.

Figure 1: Variable plots



Source: Author's calculations.

Table 4 presents the estimations obtained through multiple linear regression. The model successfully explains 60.74% of the variance in the natural logarithm of the housing price, providing a statistically reliable fit for predictive scenarios. Importantly, there is no evidence of collinearity among the relevant variables. Additionally, the White test for heteroskedasticity



yielded a *p*-value of 0.11958, indicating the absence of heteroskedasticity in the variables analysed. As multicollinearity was observed in Construction Costs and Ln Money Supply, a second model was run excluding these variables to prevent potential effects on the model, whose results are presented in Table 5.

Table 4: Multiple linear regression model estimates

Variables	Coefficients	Std. dev.	t-stats.	p-value	VIF	White test
Constant	-4.919	325.382	-1.512	0.133	-	-
Ln land price	-0.001	0.179	-0.008	0.994	5.279	0.312
IDSE	14.214	1.940	7.325	3.93×10^{-11}	4.482	0.633
m2	-0.000	0.000	-0.511	0.611	1.425	0.429
Sales	8.26×10^{-2}	1.560	0.053	0.958	3.301	0.389
Age of residential building	-0.006	0.002	-2.241	0.027	2.879	0.934
Construction cost index	-8.85×10^{-5}	0.000	-0.559	0.577	54.403	0.565
Population	-0.001	0.015	-0.076	0.939	1.726	0.880
Mortgage interest rate	-0.290	0.055	-5.287	6.23×10^{-7}	4.841	0.700
Blue-chip index (IPSA)	-3.37×10^{-5}	4.260	-0.792	0.430	5.471	0.678
Ln copper price	-0.336	0.106	-3.162	0.002	3.338	0.916
Ln money supply	0.049	0.392	0.125	0.900	88.564	0.498

Note: variables highlighted in bold are statistically significant at 0.05 level.

Source: Author's calculations.

Table 5: Multiple linear regression model estimates

Variables	Coefficients	Std. dev.	t-stats.	p-value	VIF	White test
Constant	-5.565	1.293	-4.302	3.56×10^{-5}	-	-
Ln land price	-0.080	0.150	-0.534	0.594	3.798	0.139
IDSE	15.159	1.617	9.372	7.54×10^{-16}	3.170	0.221
m2	-0.005	0.001	-0.735	0.464	1.262	0.123
Sales	-7.677×10^{-7}	1.178×10^{-5}	-0.065	0.948	1.921	0.978
Age of residential building	-0.005	0.002	-2.286	0.024	2.512	0.169
Mortgage interest rate	-0.271	0.044	-6.070	1.68×10^{-8}	3.271	0.058
Blue-chip index (IPSA)	-3.56×10^{-5}	3.98×10^{-5}	-0.896	0.372	4.869	0.519
Ln copper price	-0.313	0.095	-3.312	0.001	2.700	0.023

Note: variables highlighted in bold are statistically significant at 0.05 level.

Source: Author's calculations.



From these results, only four out of all the variables analysed were statistically relevant in explaining housing prices in Greater Santiago. Among these variables, there is no significant collinearity (VIF). The most important variable is IDSE, indicating that neighbourhoods with a lower level of socioeconomic development tend to have lower housing prices. Another influential variable is the mortgage interest. Additionally, the copper price and the age of residential buildings are also significant factors.

Chile, being a nation dependent on mineral exports, finds itself in a favourable situation when the price of copper rises. This can lead to a decrease in housing prices as a result of the positive expectations generated in the business sector by the high price of copper on the international market. On the other hand, the mortgage interest rate is a crucial factor that, in the case studied, shows that a reduction in rates increases the number of potential home buyers. However, the real estate market fails to meet the demand, resulting in price increases, which are possibly due to a shortage of supply. In this regard, the role of the Central Bank in setting rates plays a fundamental role, although it has not been directly measured in this study. The monetary policy implemented by the Central Bank can influence the regulation of housing prices.

Lastly, the age of residential buildings also has an impact on housing prices. Newer buildings tend to have higher prices, presumably because they have fewer structural problems and offer more advanced technology than older buildings do.

Discussion and Conclusions

The findings here show that the socioeconomic disparities between neighborhoods underscore the importance of addressing housing as a social justice issue, rather than solely an economic one. While lower housing prices may look like an investment opportunity from a business perspective, they also reflect the social degradation of targeted neighbourhoods for real estate investments. In the case of Chile, the state is obligated to allow the market to operate without interruption, but evidence indicates that failing to address the city's housing price inequalities perpetuates their reproduction. Decision-makers should acknowledge this observation before considering to keep the current deregulation of the housing market, as the free market in this case works against the interests of poorer households. These findings align with the results indicated by Encinas et al. (2019), highlighting the imperfections of the real estate market and the monopolistic condition of land as a pricing factor.

The high statistical significance of the mortgage interest rate reveals that the process of housing financialisation is influenced by the decisions made by the Central Bank of Chile and by other nations. The monetary policy rate directly impacts the mortgage rate, which is then determined by banks based on the risks faced by the financial market. Consequently, the Central Bank can be seen as a key player in the housing price formation process, aligning alongside financial institutions. In concrete terms, housing financialisation significantly affects access to housing security.

The Chilean economy heavily relies on the price of copper. The influential weight of the international market price of copper on housing prices, as indicated by Idrovo-Aguirre & Contreras-Reyes (2021), presents an important interpretative field for South America, considering the region's dependence on raw materials. Consequently, it is essential to investigate how this statistical relationship between copper prices and housing prices is



established. It is possible that profits from copper sales are being converted into real estate investments with the aim of generating secure long-term income and wealth. This finding suggests the need for specific territorial research, particularly in cities such as Antofagasta, Iquique, Calama, and Copiapó in the case of Chile. For other nations, it may be worthwhile exploring the influence of soy prices in Brazil and Argentina or the prices of meat in Uruguay or coffee in Colombia.

Another significant factor is the age of the residential buildings, which is the only internal element contributing to price determination in this analyses. This finding aligns with Sagner's (2009) research, which emphasised the importance of macroeconomic variables in house price formation. In this study focused on Chile, two macroeconomic variables and two microeconomic variables demonstrated statistical significance in explaining house prices. Future research could further explore these variables using different methodological strategies. Nevertheless, these results indicate the desirability of integrating micro- and macroeconomic variables into hedonic models to generate more comprehensive analyses of the causalities in the housing price formation process and markets.

Addressing the price of housing in Chile requires comprehensive public policy solutions to enhance affordability and tenure security. The research findings here indicate that the characteristics of the housing itself contribute little to price formation, while external factors have a more significant impact. The IDSE factor, which encompasses the configuration of the urban space surrounding the house and the neighbourhood in which it is located, greatly increases the value of the units for sale. This finding suggests that the value of housing is not solely determined by its design or architectural merits, but also by external factors, providing evidence for the potential social production of housing prices.



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